FEB 21 1947

INDEX NUMBER

Vol. 20 ©C1B 62633 DECEMBER, 1946 No. 6

SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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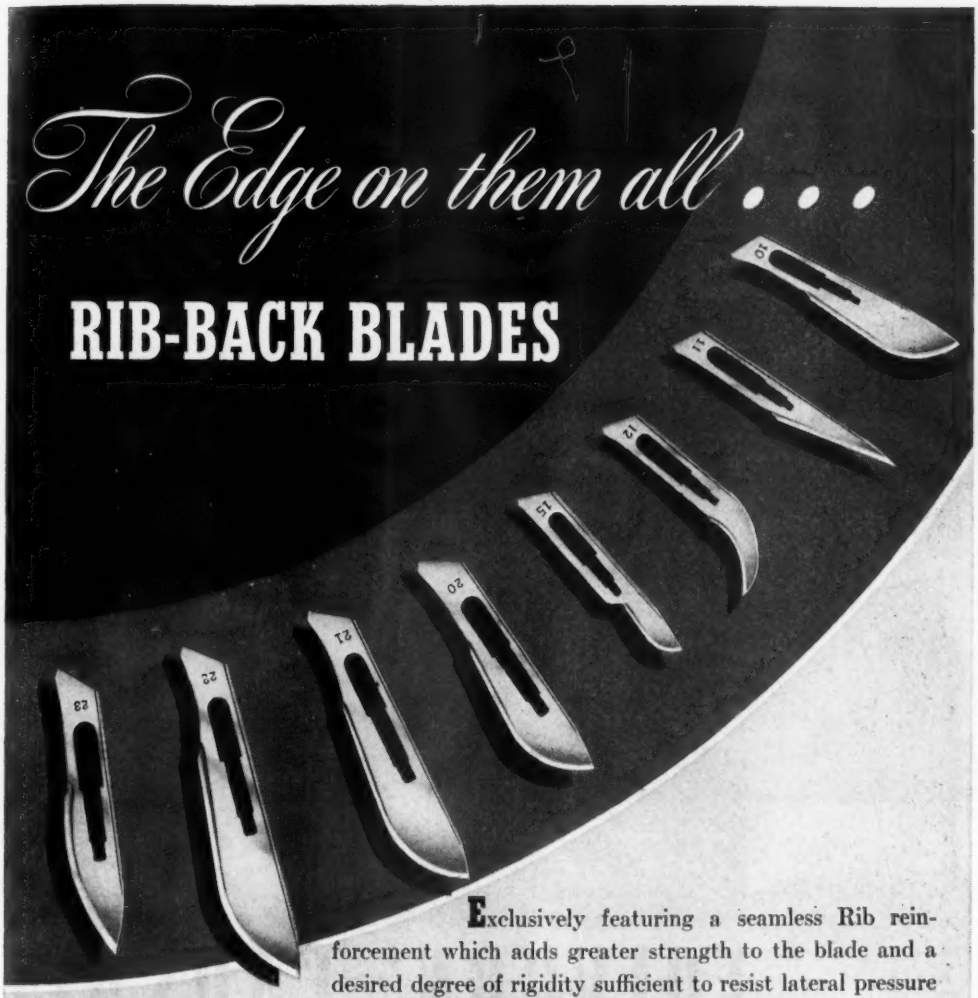

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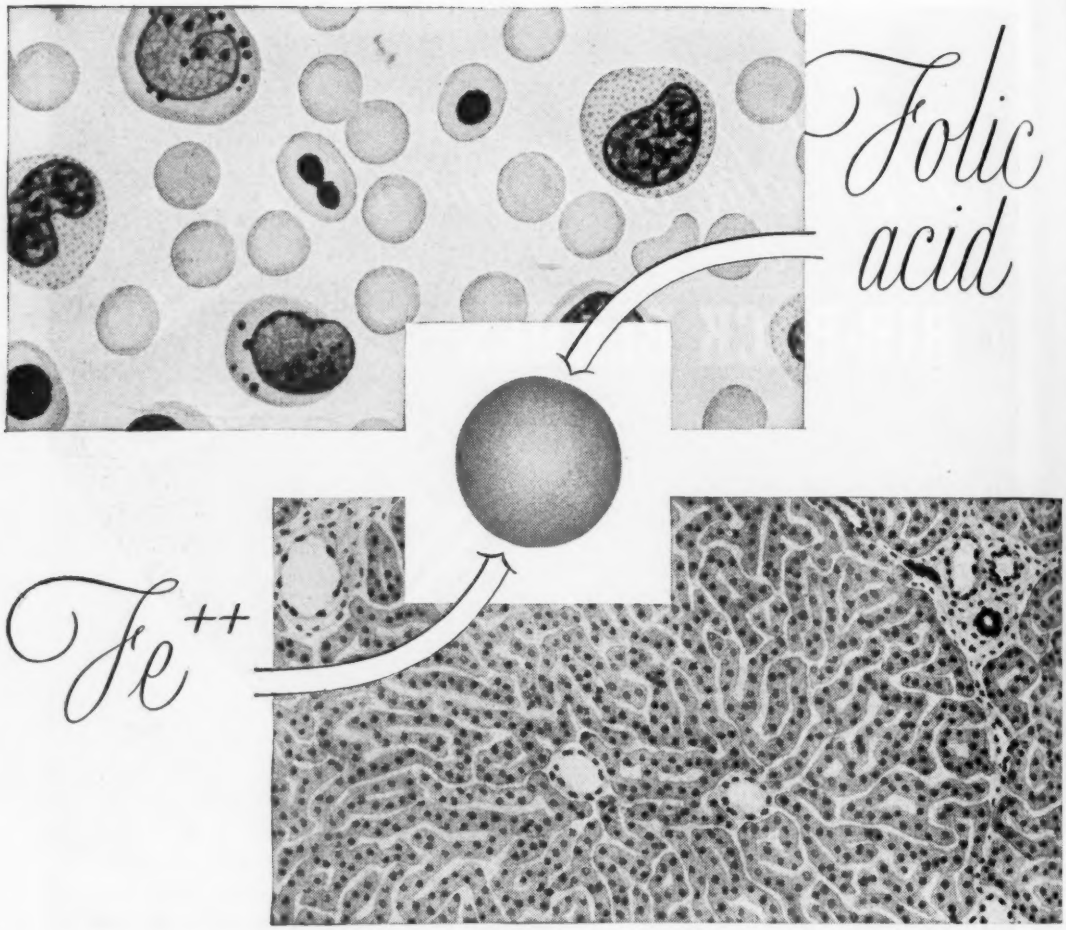

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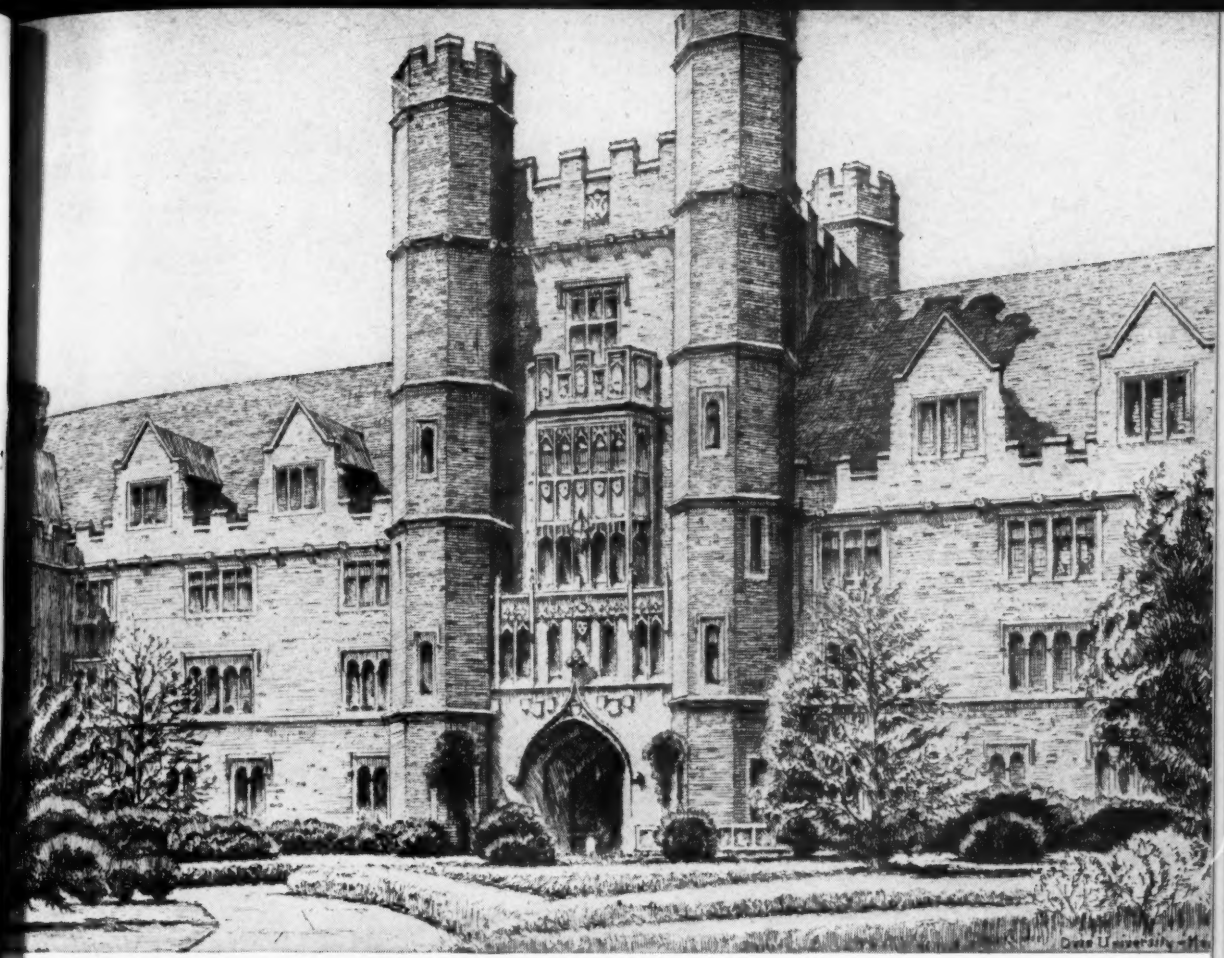

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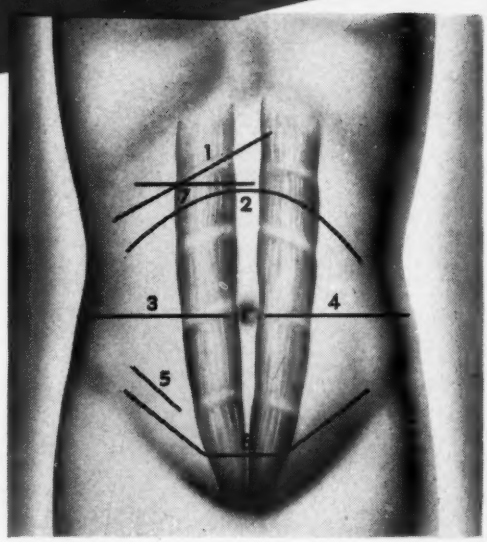

1. For gall bladder, common duct, head of pancreas.
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3. Resection of ascending colon, cecum, right sided lesions.
4. Descending colon, spleen and left sided lesions
5. Appendectomy.
6. Pelvic surgery, resection of sigmoid.
7. Small exploratory transverse incision.

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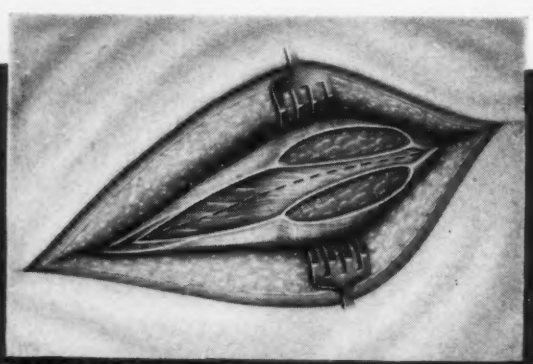
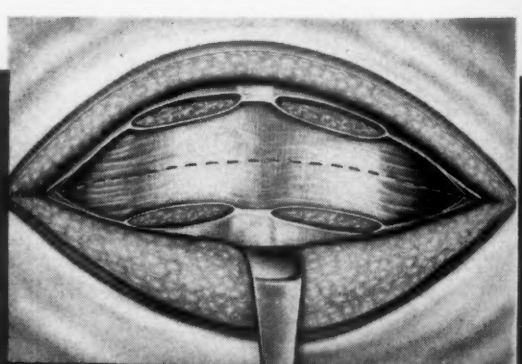
A resumé of the principles involved, together with some pictures describing the incisions, are shown on these two pages. This series covers the principles as they relate to the abdominal section of the body.



Line of incision in posterior sheath and peritoneum in gall bladder incision.



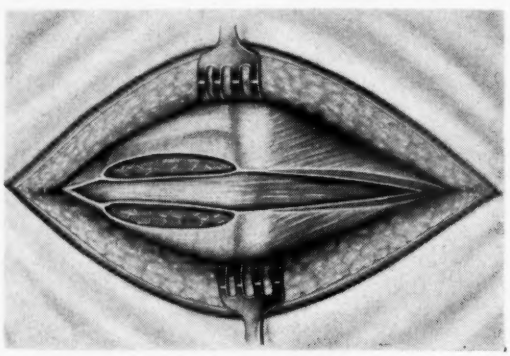
Incision in peritoneum in gastrectomy incision.

ADVANTAGES OF TRANSVERSE INCISIONS

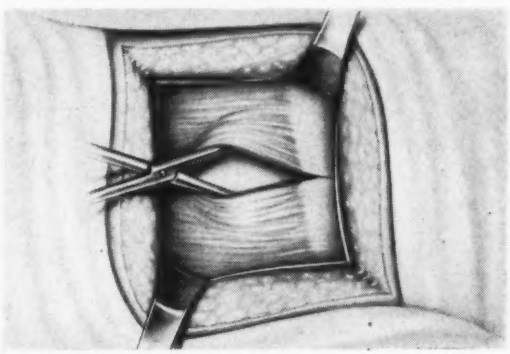
SUTURES hold more securely if the connective tissue layers within the wound are approximated in such a manner that the sutures must pull against the fibers within them. Sutures pull against the fibers only when the connective tissues are cut parallel to the direction of the fibers. In the anterior abdominal wall, this is usually best accomplished through a transverse incision. As a result, sutured transverse incisions are stronger than sutured vertical incisions.

In the past, transverse abdominal incisions did not find a wide acceptance because they necessitated cutting across muscle. Attempts were made to suture the muscles and the sutures not only held poorly, but they almost invariably caused necrosis.

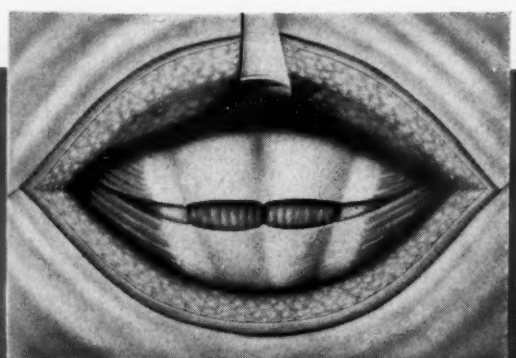
In the new technic, no attempt is made to suture muscles—only the surrounding sheath. Necrosis is thereby avoided. Some approximation of muscle is obtained by suturing their sheath, and further approximation is accomplished by keeping the patient in a semi-reclining position with knees partially reflexed.



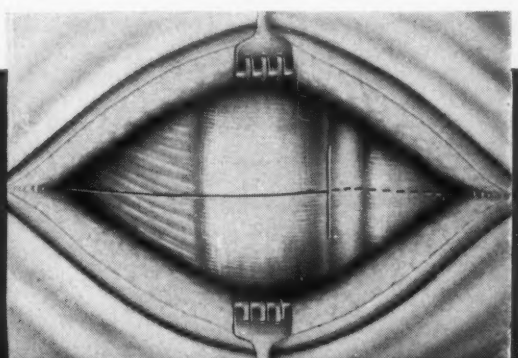
Cut rectus muscle in the incision for resecting the descending colon.



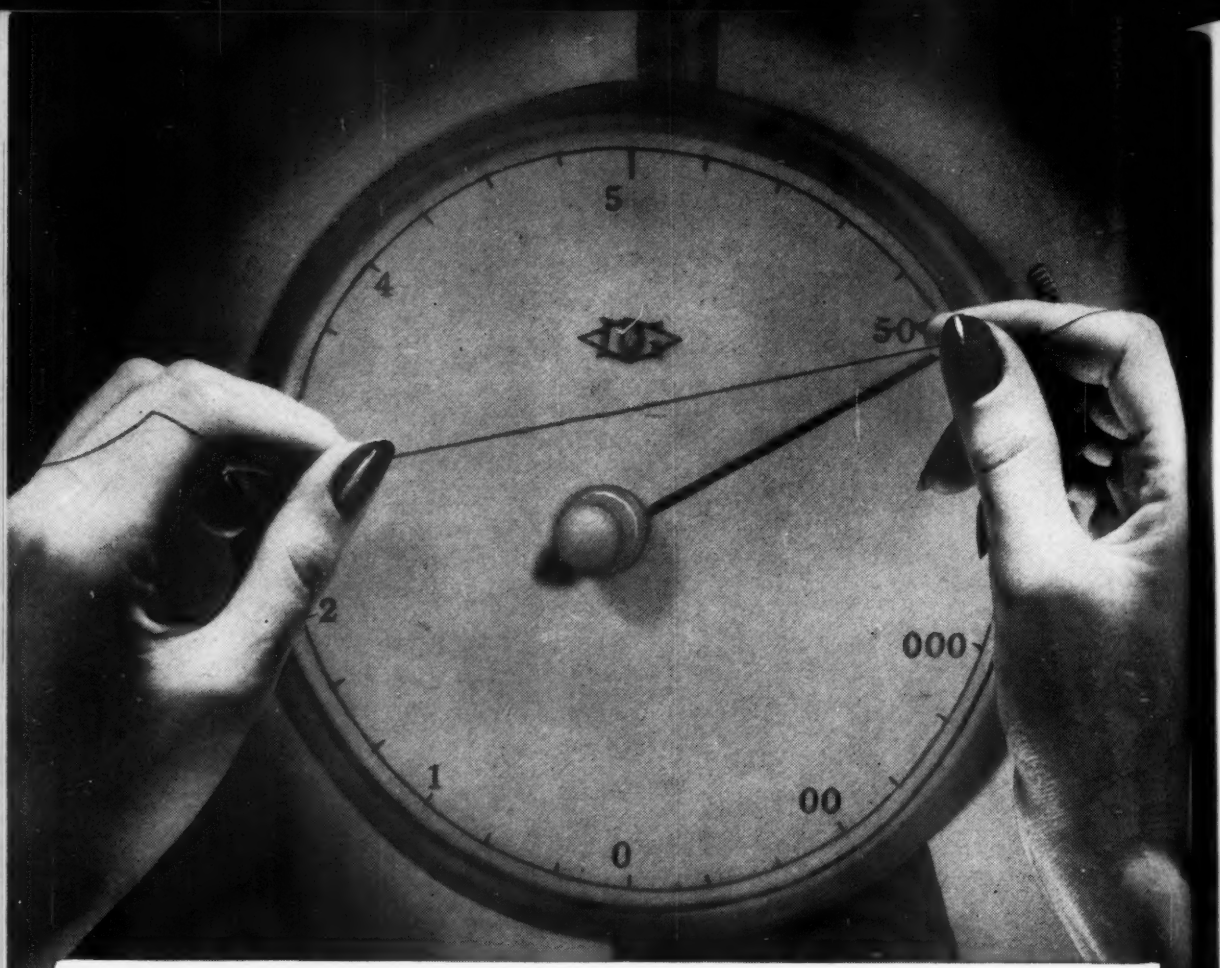
Separating muscle fibers in McBurney incision.



Cutting the fascia of the anterior sheath in lower abdominal transverse incision.



Incision in anterior rectus sheath with possible extension.



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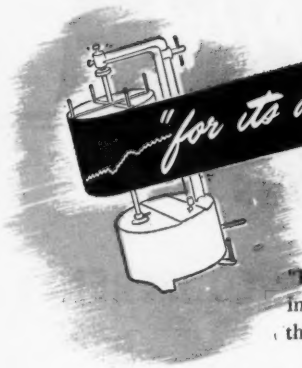

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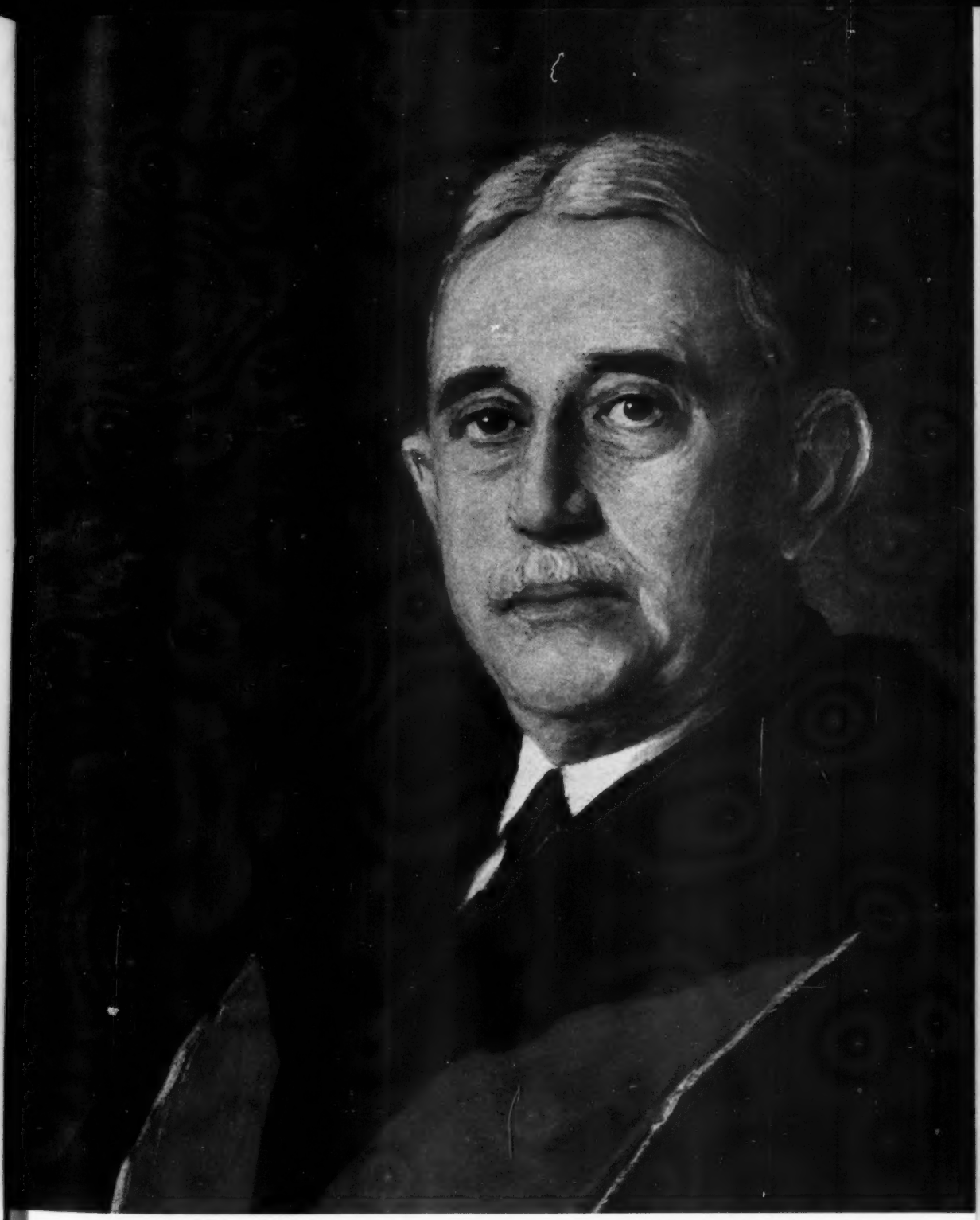

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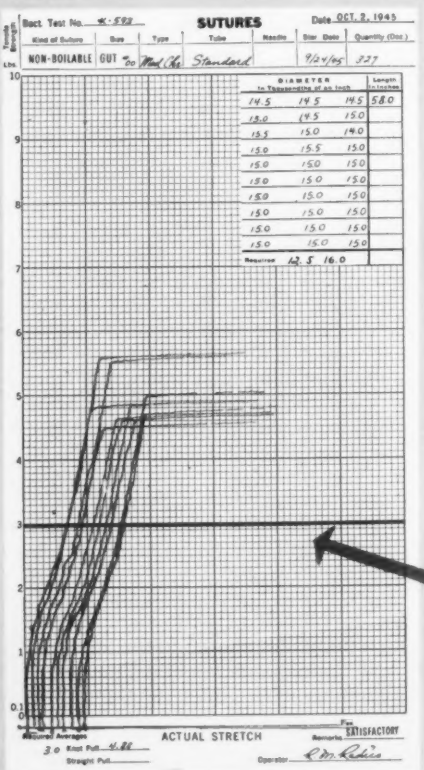

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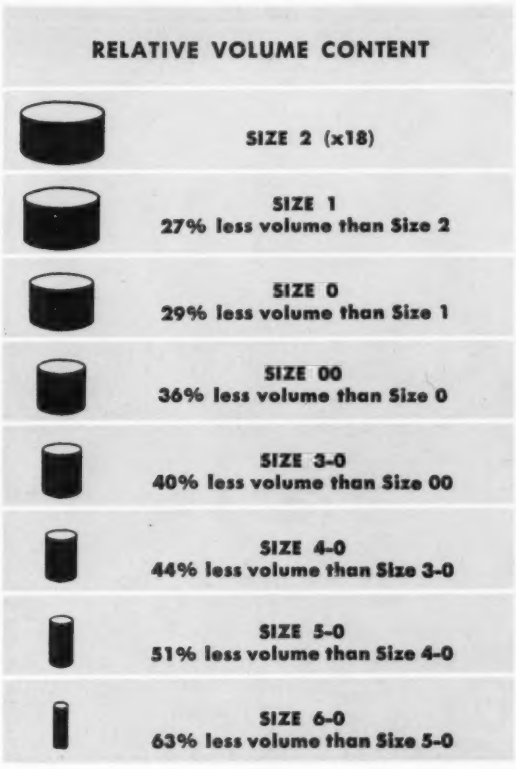

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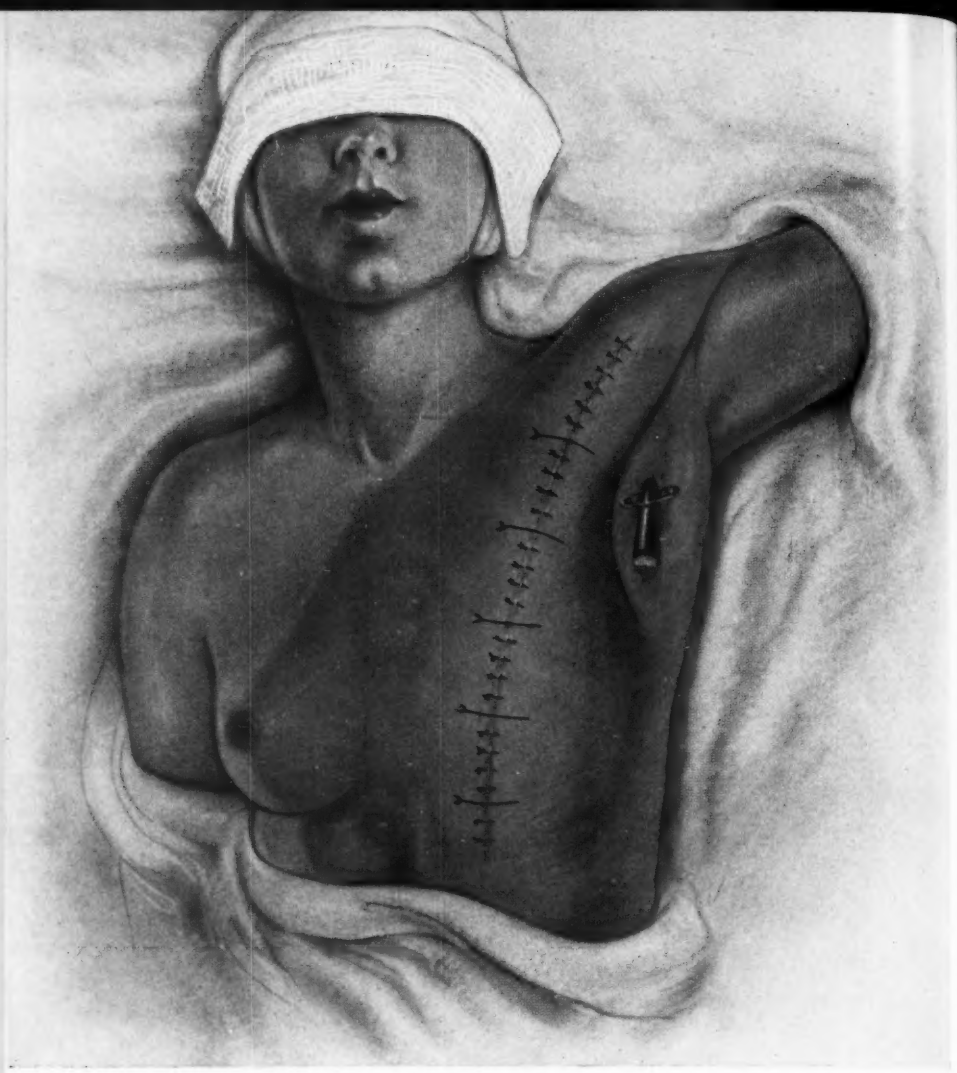

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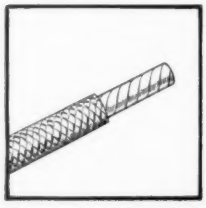

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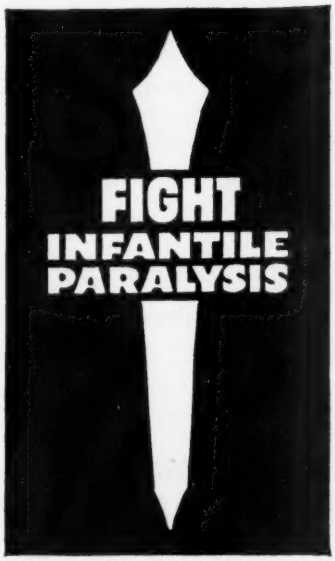

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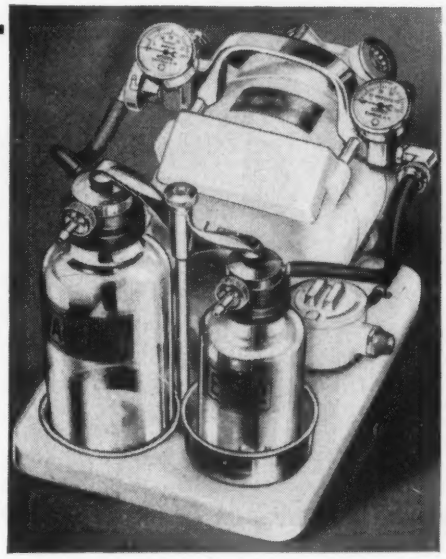

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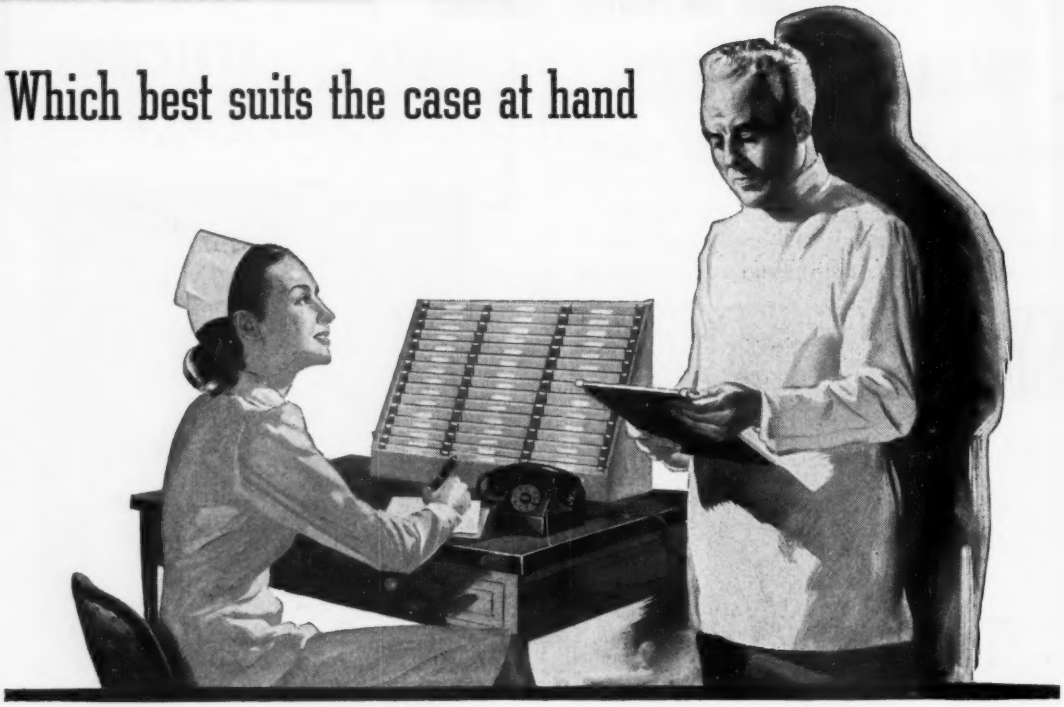

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SURGERY

VOL. 20 DECEMBER, 1946 NO. 6

Original Communications

AN ANALYSIS OF THE EXPERIENCE WITH STREPTOMYCIN THERAPY IN UNITED STATES ARMY HOSPITALS

PRELIMINARY REPORT

COLONEL MICHAEL E. DEBAKEY* AND CAPTAIN EDWIN J. PULASKI†
MEDICAL CORPS, ARMY OF THE UNITED STATES

IN AUGUST, 1945, when streptomycin first became available in limited amounts, the Office of the Surgeon General of the Army, following a recommendation of the National Research Council Committee on Therapeutic and Other Agents, established a program to study the effect of this new agent in certain types of infection which had been found resistant to other forms of chemotherapy. The clinical investigation was carried out at thirty general hospitals, in one of which, Halloran General Hospital, a special investigative unit was established for an intensive laboratory, as well as clinical, study of streptomycin, somewhat along the lines of the similar investigation of penicillin carried out earlier at the same institution.‡ Special facilities were provided and special personnel assigned to this project under the direction of Captain Edwin Pulaski, whose observations and results are reported in a separate communication.

Because of the limited availability of the drug, and in order to ascertain as precisely as possible its value and limitations, every effort was made to design the program so that the drug would be used intelligently and economically. A second objective of the program was to standardize the therapeutic use of streptomycin at the earliest possible date.

The plan of investigation included, in addition to a detailed clinical history and complete physical examination prior to the initiation of treatment:

1. Identification of the etiologic organisms
2. Determination of sensitivity to streptomycin of the causal organisms

Received for publication, Aug. 19, 1946.

*From the Office of the Surgeon General, Washington, D. C.
†From Halloran General Hospital, Staten Island, New York, N. Y.

‡Lyons, Champ: Penicillin Therapy of Surgical Infections in the U. S. Army; A Report, J.A.M.A. 123: 1007-1018, 1943.

3. Complete blood studies, urinalyses, renal function tests, and other preliminary studies, such as blood cultures, spinal fluid examinations, and roentgenograms, which would provide the basis for an accurate determination of the course of the disease

After the initiation of therapy the streptomycin content of body fluids, such as blood, urine, and spinal fluid, was assayed at frequent enough intervals to be certain that the drug was being absorbed and that adequate levels were maintained. At the conclusion of treatment whatever tests were necessary for the proper evaluation of therapy were carried out.

A special clinical record form was devised which permitted simple, rapid assembly of data for analysis. All forms were returned to the Office of the Surgeon General after the completion of treatment.

The present communication is concerned with an analysis of 706 cases of various types of infection (Table I) and represents the cumulative experience of the thirty Army hospitals which participated in the streptomycin investigation from the institution of the program in August, 1945, to the present time.

TABLE I. SUMMARY OF STREPTOMYCIN-TREATED PATIENTS IN U. S. ARMY HOSPITALS

	NUMBER OF CASES	RESULTS OF THERAPY		
		IMPROVED	UNIMPROVED	DIED
Urinary infections	364	141	218	5
Wound infections	179	72	105	2
Colitis	34	21	9	4
Peritonitis	30	24	3	3
Bacteriemia	16	13	2	1
Meningitis	7	5	0	2
Tuberculosis	15	4	9	2
Brucellosis	13	2	11	0
Typhoid fever	6	3	2	1
Tularemia	2	2	0	0
Others	40	27	12	1
Total	706	314	371	21

METHODS OF ADMINISTRATION AND DOSAGE

Streptomycin salts (hydrochloride, sulfate) are dispensed as fine light yellow powders, in the dry state, in vials containing 1 Gm. (1,000,000 S units), 0.5 Gm. (500,000 S units), or 0.25 Gm. (250,000 S units). For administration, the drug is dissolved in physiologic salt solution, usually to make a 10 per cent solution. Streptomycin solutions are thermostable, and neither the powder nor the solutions show appreciable loss of potency at room temperature for periods of one month. It is well, however, to store solutions in the refrigerator when not in use.

The intermittent method of intramuscular administration has been most commonly employed and is considered preferable. With intermittent therapy there is a supplementary peak of streptomycin well above the constant maintenance level; this may be of therapeutic value and may assist the penetration of streptomycin into relatively avascular tissue. The deltoid, gluteus, and thigh muscles are best suited for the injections, and it is advisable to rotate the doses between the sites. The average duration of treatment and the total dosage

will vary with the individual case and the response to treatment. Some patients were successfully treated with a dose as low as 125 mg. (125,000 S units) every three hours by intramuscular injection. It was, however, only with doses of 300 to 500 mg., given every three or four hours, that the results became more consistent. Four hundred milligrams given intramuscularly every four hours produce a maintenance serum level of 16 μg (S units) per cubic centimeter and a mean urinary level of 1,000 μg (S units) per cubic centimeter. Renal insufficiency raises the serum level and retards the urinary excretion. The intravenous method of administration has no advantage over the intramuscular method and may produce a dangerous fall of blood pressure. It is not recommended.

Because it does not diffuse readily into the meninges, the pleura, and the bowel, streptomycin has been employed locally to provide effective concentrations in infections involving these tissues. In the meninges and in the pleura, 50 to 100 mg., dissolved in isotonic saline solution, are instilled once or twice daily. This is in conjunction with parenteral administration in the aforementioned doses. For enteric infections, streptomycin is dissolved in water and is administered orally in 2 to 4 Gm. daily doses, given at six-hour intervals.

For local or topical use, streptomycin has been employed in various media, using concentrations of the drug equivalent to 2.5 to 5 mg. per cubic centimeter or gram of medium. In general, this method of administration is not considered of much value except under certain circumstances discussed later.

The methods of administration and dosage employed in the cases analyzed have followed the principles just described, unless otherwise specified in the special categories to be considered.

URINARY TRACT INFECTIONS

Patients with urinary tract infections (Table II) represent the largest single group treated with streptomycin and account for more than 50 per cent of the total number. The explanation of the high incidence is the large number of paraplegic patients under treatment in Army hospitals and the high proportion of urinary tract infections associated with paraplegia. Mixed infections were the rule in these cases (Table III). Of the presenting bacteria, aerogenes, coli, and Friedländer's organisms were most consistently eradicated. The urinary tract was usually sterilized of the remaining bacteria if conditions were suitable, but larger dosages of streptomycin were required.

The disproportion in the results obtained with streptomycin in the paraplegic and nonparaplegic groups is striking but readily explained. Para-

TABLE II. STREPTOMYCIN THERAPY IN INFECTIONS OF THE URINARY TRACT

	WITH SPINAL CORD INJURY				WITHOUT SPINAL CORD INJURY			
	NUMBER OF CASES	IMPROVED	UNIMPROVED	DEATHS	NUMBER OF CASES	IMPROVED	UNIMPROVED	DEATHS
Without calculi	160	56	104	0	98	68	29	1
With calculi	47	5	41	1	26	4	20	2
With abscess or cellulitis	14	1	13		10	1	8	1
Total	221	62	158	1	134	73	57	4

TABLE III. INCIDENCE OF AEROBIC PATHOGENIC BACTERIA IN URINARY TRACT INFECTIONS (355 CASES)

	NUMBER OF TIMES RECORDED	PERCENTAGE
Aerobacter aerogenes	170	25
Escherichia coli	132	19
Proteus vulgaris	115	17
Nonhemolytic streptococcus	83	12
Pseudomonas aeruginosa	70	10
Staphylococcus aureus	58	9
Klebsiella pneumoniae	32	5
Hemolytic streptococcus	20	3
Total	680	100

plegic patients present conditions unfavorable for permanent cure. They have open wounds, residual urine, and ureteral refluxes, and their treatment necessitates the use of tubes and catheters. Under the circumstances any beneficial effects of therapy are likely to be neutralized rapidly because of the unusual opportunities afforded for reinfection or reactivation of the infection after the drug is discontinued. Many patients listed as unimproved showed symptomatic and clinical improvement as long as streptomycin therapy was continued.

In Table II it is suggested that calculi or other obstructive lesions and undrained abscesses also militate against effective streptomycin therapy. They are inaccessible or resistant foci and, in order to prevent the rapid development of drug-fastness, streptomycin is contraindicated until they are corrected from the standpoint of relief of obstruction.

There were 5 deaths in the 364 patients with urinary tract infection. Two patients had bilateral urinary calculi, in one instance of the staghorn variety, had been ill for many months, and presented marked malnutrition, cachexia, anemia, and urinary sepsis. The third patient had paraplegia with extensive abscesses of the renal cortex. The fourth had a retrovesical abscess which ruptured into the peritoneal cavity, producing generalized peritonitis. The fifth patient, who had chronic pyelonephritis, died on the tenth day after the institution of streptomycin therapy, apparently of hepatitis, which had been present for several months, and of terminal bronchopneumonia. He was in extremely poor condition, with severe cachexia, anemia, and sepsis, when treatment was begun. All five patients received adequate amounts of streptomycin.

Especially interesting is the small but highly significant group of nine cases of urethritis included in this series (Table IV). Of particular importance is the fact that in all five cases of gonococcal origin, prompt clinical improvement and apparent cure were obtained with streptomycin, although all the patients had previously been treated with adequate dosages of sulfadiazine and penicillin without success.

TABLE IV. STREPTOMYCIN THERAPY IN URETHRITIS

TYPE	NUMBER OF CASES	IMPROVED	UNIMPROVED
Nonspecific	4	1	3
Gonorrheal	5	5	0

Analysis of these cases of urinary tract infection seems to show quite clearly that streptomycin is a very useful agent in infections produced by bacteria susceptible to the drug if they are not associated with obstruction, retention of residual urine, and undrained or unsterilizable foci. In other words, the successful use of streptomycin in urinary tract infections depends upon a normal flow of urine. Moreover, the drug must be used early and in adequate dosages, particularly with infections due to the enterococcus and pseudomonas, since habituation of the organism occurs rapidly and is a constant feature of cases in which the concentration of streptomycin in the urine is inadequate. It would also appear that streptomycin may be a highly useful therapeutic agent in gonococcal infections, especially those which prove resistant to penicillin and sulfadiazine.

WOUND INFECTIONS

Wound infections, which numbered 179, represent the second largest category of cases. All the wounds were combat-incurred and most of them were associated with chronic osteitis and fibrosis and impoverished local circulation. Polymicrobial flora were usually present, staphylococci and streptococci being almost invariably identified, with Clostridia present in about one-third of all cases. A variety of gram-negative bacteria of the fecal type were associated, including proteus, coli, Pseudomonas, and aerogenes.

Various combinations of systemic and topical administration of the drug were employed, no vehicle for topical application being completely free of clinical objections. Complete sterilization of the wound was rarely achieved. Extensive fibrosis of soft tissue and sclerotic changes in bone reduce vascularity and lessen permeability so that sufficient contact of the streptomycin with the causative organism must occur infrequently regardless of route of administration. Probably of even greater importance in contraindicating the local use of streptomycin or any chemotherapeutic agent in wound management are such factors as the inevitable discharge of wound secretions and microscopic sloughs offering a medium for the growth of air-borne contaminants, the presence of wound recesses and pockets, the repeated occurrence of small blood clots incident to wound dressing, and the locally destructive effects of retained products of suppuration.

Of the 179 cases in this series, 72 patients (40 per cent) were listed as improved while the remainder were definitely not benefited by streptomycin therapy. Of those listed as improved, however, careful review of the records showed that the improvement was, in most instances, coincident with apparently adequate wound revision. Accordingly, it is quite evident that streptomycin does not differ in any way from other chemotherapeutic agents with regard to its place in the management of wound infections. Adequate surgery, supplemented upon indication with specific chemotherapy, is still the chief therapeutic measure under these circumstances.

There were two deaths, one due to an error in intravenous technique, the other to a ruptured retroperitoneal abscess; neither could be attributed to streptomycin therapy.

OTHER INFECTIONS

The remaining 163 patients treated with streptomycin (Table I) include only small numbers in each category. Data in most of these cases are not sufficient to be statistically significant and definite conclusions cannot be drawn from such limited observations. Nonetheless, the results obtained indicate certain trends and are reported for this reason and in order to add the data to the accumulating experience with streptomycin therapy.

ENTERIC INFECTIONS AND COLITIS

Under the heading of enteric infections and colitis are listed three different categories, with results as presented in Table V.

TABLE V. STREPTOMYCIN THERAPY IN ENTERIC INFECTIONS AND COLITIS

	NUMBER OF CASES	IMPROVED	UNIMPROVED	DEATHS
Dysentery due to Shigella paradysenteriae	5	5		
Chronic ulcerative colitis, nonspecific	16	6	9	1
Epidemic diarrhea of infants	13	10	0	3

The five patients with dysentery caused by Shigella showed a prompt, effective response to streptomycin therapy.

Of the nonspecific ulcerative colitis cases, six patients were temporarily benefited by streptomycin administered by the combined oral and intramuscular routes, but the results were not permanent, and there was no improvement as evidenced by sigmoidoscopic examination. Nine patients showed no improvement and one died from a pulmonary embolus 6½ days after streptomycin therapy was begun.

Thirteen infants under 3 months of age received oral streptomycin therapy. All had severe epidemic diarrhea with dehydration and shock. Ten survived and three died. In four of these cases it seemed likely that survival could be attributed to the effects of oral administration of streptomycin.

Apparently, if the specific organism in colitis can be identified and is sensitive to streptomycin, the results of treatment are likely to be impressive. If the organism cannot be identified, it is difficult to assign any credit to the drug for possible clinical remissions. Moreover, streptomycin does not influence irreversible pathologic changes in the bowel.

PERITONITIS

Twenty of the thirty cases of peritonitis (Table I) treated with streptomycin were of appendical origin; approximately one-half were localized or localizing. The ten remaining cases were due to perforated viscera consequent to trauma or operation. In most cases the infection was due to mixed organisms of fecal origin.

Improvement was recorded in twenty-four cases, sixteen of which were of appendical origin, and no improvement was observed in three, two of which followed appendicitis. Three deaths occurred, one in a patient with appendicitis,

presumably from pulmonary embolism, and two in patients with generalized peritonitis who had been treated one and three days, respectively. In one of the latter cases the disease was also of appendical origin.

The number of cases in this category is too small to permit definitive statements, but evidently streptomycin does not produce dramatic results in peritonitis, although its use as an adjuvant to standard surgical measures seems temporarily justifiable in an effort to provide final evaluation.

BACTERIEMIA

Sixteen patients with bacteriemia (Table VI) were treated in the course of the investigation. In eight the focus was in the kidney and in two it was in bone. The remaining six cases included such conditions as bacteriemia following the extraction of a tooth and postabortal sepsis. Thirteen patients were improved, two were unimproved, and one died of sepsis.

TABLE VI. RESULTS OF STREPTOMYCIN THERAPY IN BACTERIEMIA

ETIOLOGIC AGENT	NUMBER OF CASES	RESULTS		
		IMPROVED	UNIMPROVED	DEATHS
Aerobacter aerogenes	4	3	1	
Klebsiella pneumoniae	3	3		
Pseudomonas aeruginosa	1	1		
Paracolon bacillus	2	1	1	
Streptococcus viridans	2	2		
Staphylococcus aureus	3	2		1
Gram-negative bacillus (Identity?)	1	1		
Total	16	13	2	1

All the patients who improved had organisms which were sensitive to streptomycin, all had eradicable foci, and all received adequate amounts of the drug. The two patients who did not improve had foci difficult to sterilize (renal abscesses with calculi) and had inadequate doses of streptomycin. The patient who died had a disseminated staphylococcic sepsis of undetermined origin, with multiple abscess formation. The organism was sensitive and therapy was adequate, but the sepsis was overwhelming.

The results in this small series of cases warrant further use of the drug in bacteriemia if the organism in the case is sensitive to it. In such cases dramatic results should follow adequate therapy, since appropriate blood levels are readily maintained following intramuscular injections of streptomycin.

TUBERCULOSIS

Seven of the fifteen patients (Table VII) in the group with tuberculosis had infections of the urinary tract, four had spreading pulmonary disease, three had meningitis, and one had cutaneous tuberculosis. Four patients were improved, apparently as the result of streptomycin therapy in combination with other measures. Two of these patients had renal tuberculosis and following treatment the urine became sterile. Whether the improvement will be permanent it is too soon to say. The most suggestive evidence of the effects of therapy were obtained in two cases, one of pneumonia and one of meningitis of tuberculous

TABLE VII. STREPTOMYCIN THERAPY IN TUBERCULOSIS

TYPE	NUMBER OF CASES	RESULTS		
		IMPROVED	UNIMPROVED	DIED
Renal	7	2	5	
Pulmonary	4	1	3	
Meningeal	3	1		2
Cutaneous	1		1	
Total	15	4	9	2

origin, in which the course is usually rapidly downhill. Since the patient with pneumonia improved promptly after streptomycin therapy was begun, it seems fair to assume that treatment in this instance was lifesaving, although whether arrest of the disease was due to control of the tuberculosis or to effective inhibition of secondary invaders it is not possible to say. The other patient who showed striking improvement had tuberculous meningitis and at the time of this writing, three months after treatment, has clear spinal fluid and no evidence of reactivity. The two deaths in the series, however, occurred in patients with tuberculous meningitis. There was no improvement in the one patient with cutaneous tuberculosis.

The nine surviving patients in the series who showed no improvement may have received inadequate therapy, in respect to either dosage or duration, or had organisms with natural or acquired resistance, or inaccessible foci. Some of these factors contributed to failure in all cases, while in a few cases all seemed operative.

This series is obviously too small to permit conclusive statements concerning the efficacy of streptomycin in tuberculosis. It seems fair to say, however, on the basis of the striking improvement that followed the use of streptomycin in a few of the cases, that further and more intensive studies in the use of streptomycin in tuberculosis are warranted.

BRUCELLOSIS

In four of the thirteen patients with brucellosis treated with streptomycin, positive blood cultures were obtained. In the remainder, diagnosis was based on high titer agglutinins in the blood, or strongly positive brucellergin skin reactions, or both. Two of the patients had fairly prompt remissions after treatment and their blood cultures became negative. Brucellosis, however, is characterized by remissions, and the follow-up has not been long enough to justify any statement of results. In the remaining eleven cases neither the symptoms nor the course of the disease seemed influenced by therapy.

It is doubtful whether streptomycin, regardless of the dosage employed, can penetrate foci of infection in brucellosis. It is doubtful, also, that treatment by this means is justified in any case, except possibly in the acute phase of the disease.

MENINGITIS

In the seven cases of nontuberculous meningitis treated with streptomycin, the etiologic agents were variously *Aerobacter aerogenes, Escherichia coli,*

Haemophilus influenzae, hemolytic streptococcus, *Pseudomonas aeruginosa,* and *Staphylococcus aureus, Proteus vulgaris,* and *Cryptococcus hominis.* Five patients recovered and two died. One, who had an infection with *A. aerogenes* secondary to laminectomy, was moribund when streptomycin was first administered and was treated only 9½ hours. The other had an infection with *C. hominis,* which is insensitive in vitro to streptomycin as well as to penicillin and sulfadiazine.

The results in this small group of cases, therefore, suggest that streptomycin is a valuable therapeutic agent in meningitis. It is imperative, however, (1) that the organisms be of proved sensitivity, and (2) that the drug be introduced directly into the cerebrospinal circulation.

TYPHOID FEVER

Of six patients with confirmed typhoid fever, three improved, two of whom showed brilliant results. In both, treatment was instituted within two weeks of the onset of symptoms. The third patient, who had a bacteriemia, apparently secondary to osteomyelitis due to *Eberthella typhosa,* had good results from a combination of streptomycin and appropriate surgery. Of the remaining three patients, two were carriers with positive stool cultures and no permanent benefits from streptomycin therapy. One patient died, after fourteen days of therapy in adequate dosage, of generalized peritonitis following perforation of a typhoid ulceration of the ileum.

The sharp contrast between the good results of treatment in the acute stage, and the poor results in the chronic stage, of the disease suggest that when once the infection has localized, the foci are not sterilizable and success is not likely to occur.

TULAREMIA

Of two patients with proved tularemia, one, whose disease was of the pneumonic type, responded promptly and dramatically to streptomycin. The other, whose disease was of the ulceroglandular type, required two weeks of treatment before resolution occurred. The results in these two patients support the published observations that streptomycin promises to be a potent therapeutic aid in the treatment of tularemia.

PLEUROPULMONARY INFECTIONS

Of the nine patients in this group, five had pneumonia and four empyema. In the five cases of pneumonia the etiologic agent was recorded as *K. pneumoniae* (Friedländer's bacillus, *Bacillus mucosus capsulatus*) in two cases, and as pneumococcus of undetermined type in the third case. The fourth case presented a mixed infection and in the fifth case culture was not reported. All the patients showed improvement. The organisms isolated were sensitive in vitro to streptomycin and the results of therapy were most encouraging.

Of the four patients with empyema, three improved and one died of generalized sepsis of peritoneal orgin. It seems important to emphasize the fact that in all of the cases in which improvement occurred the drug was employed in conjunction with adequate surgical drainage.

OTITIS EXTERNA

The six cases in this group all presented polymicrobial flora, including gram-positive and gram-negative varieties. All cases were treated by local measures, chiefly by wicks saturated with streptomycin solution and renewed two to four times daily. Improvement followed in all but one case, in which the organisms were insensitive.

MASTOIDITIS

In all three cases of mastoiditis the infection was polybacterial, due to *A. aerogenes, Staph. aureus, P. vulgaris,* and *Ps. aeruginosa.* Two patients showed improvement and one did not. The results were not striking in any case, and such improvement as did occur was possibly coincident with the establishment of adequate drainage.

BRAIN ABSCESS

Two of the four cases of brain abscess were due to penetrating wounds, one was due to pansinusitis, and one was of undetermined origin. The etiologic agents were *Staph. aureus* in two cases with *Ps. aeurginosa* associated in one, *P. vulgaris* in the third case, and anaerobic hemolytic streptococci and anaerobic gram-negative bacilli in the fourth case.

Three patients were improved, although in each case improvement was secured only when parenteral administration was supplemented by drainage of the abscess and local instillation of streptomycin after evacuation of pus. It would seem that the systemic administration of streptomycin can achieve little in this type of case unless it is supplemented by local administration, perhaps because the circulation does not permit the concentration of effective levels of the drug in abscesses. The fourth patient showed no improvement, perhaps because bony and metallic foreign bodies were not removed from the wound.

MISCELLANEOUS CASES

Eighteen cases of various conditions were placed in this category. Four were instances of cutaneous disease. One case of blastomycosis and another of pemphigus showed no improvement. In the other two cases, one of generalized furunculosis and one of acneiform ulceration, neither of which had responded to penicillin, improvement was recorded.

In one case of acute cholecystitis, streptomycin therapy was employed in adequate dosage, 30 Gm. over a period of sixteen days, without striking results. Improvement occurred in this case only after cholecystectomy was performed.

One case of Hodgkin's disease terminated fatally. Streptomycin was administered for seven days prior to death, apparently as a "panic" measure.

One patient with liver abscess, in which the etiologic agent was an anaerobic nonhemolytic streptococcus, showed improvement only after surgical drainage was instituted. It is doubtful that streptomycin was of much value.

The remaining eleven cases in this group were localizing soft-part infections of various kinds. Improvement was recorded in six and no improvement in five cases. All the unimproved cases were associated with insensitive bacteria, inadequate surgery, or inadequate drug therapy.

REACTIONS TO STREPTOMYCIN

The reactions reported following the systemic administration of streptomycin are shown in Table VIII. The greatest number was in the form of headaches, joint pains, and skin reactions, which, while annoying, were transient, disappeared on withdrawal of the drug, and usually responded to symptomatic treatment. Histamine-like reactions, manifested chiefly by a fall in blood pressure, are uncommon with batches of streptomycin now available. The effects of streptomycin on the kidney, manifested by proteinuria, cylindruria, and hematuria, and occasional azotemia, disappeared on withdrawal of the drug. On the basis of these experiences the renal irritation effect of streptomycin should not be regarded as a cause for interruption of therapy, if the kidneys are normal. The two cases of vestibular disturbance were the only instances of serious toxicity, producing permanent damage, associated with streptomycin therapy. Whether additional cases occurred and were not recognized, or were adequately compensated for, is difficult to determine. A more careful and systematic investigation of this complication is now in progress. Vestibular disturbance is the only complication presently considered to be an indication for termination of drug therapy.

TABLE VIII. REACTIONS TO STREPTOMYCIN IN 706 TREATED PATIENTS

	NUMBER OF CASES AFFECTED	PER CENT OF TOTAL
Headaches, severe	39	5.5
Skin reaction—urticaria, local or generalized rash, eosinophilia, fever	30	4.2
Arthralgia, generalized	30	4.2
Dizziness	20	2.8
Anorexia, nausea and vomiting, abdominal pain	11	1.6
Alterations in urine: albumin, casts, W.B.C., R.B.C.	11	1.6
Blood pressure, fall in (20 mm.)	10	1.4
Vestibular disturbance	2	0.28

SUMMARY

1. An analysis is presented of the experience with streptomycin therapy in thirty United States Army hospitals during the period August, 1945, to May, 1946, inclusive. The analysis is based upon 706 cases of infections of various kinds, in all of which complete records were made and submitted to the Office of the Surgeon General.

2. In the treatment of these cases, streptomycin was administered parenterally, locally, orally, or in combination, depending on the type of infection. For systemic administration, the intermittent intramuscular method is preferred. The dosage employed ranged from 1 to 3 Gm. per day, given at three or four hourly intervals. The larger doses generally proved to be more effective. In meningitis and empyema, doses of 50 to 250 mg. in sterile isotonic saline solution, administered once or twice daily into the spinal canal or pleural cavity, were used. For topical application, concentrations of 2.5 to 10 mg. per gram of medium were employed. The oral route was used in enteric infections with a total of 2 to 4 Gm. daily, given in divided doses, every six hours.

3. Systemic administration of streptomycin in the doses cited was found to maintain therapeutically effective levels in blood and urine. Intrathecal and intrapleural administration proved essential for the effective treatment of infections involving the meninges and pleura, respectively. In enteric infections, the drug must be given orally. In most infections the combined route of administration was found essential. Topical use of streptomycin has not been attended by strikingly beneficial results, and in most cases proved to be of little value.

4. In urinary tract infections due to susceptible bacteria, streptomycin has proved to be a very useful agent. Its successful use, however, depends upon a normal flow of urine. Recurrent urinary tract obstruction, urinary retention, and undrained or unsterilizable foci, including the prostate, predisposed to relapse or reinfection. Treatment under these circumstances produced rapid and irreversible drug-fastness.

5. Streptomycin would appear to be a highly useful agent in gonococcal urethritis, especially in those cases which prove resistant to penicillin and sulfadiazine.

6. Relatively extensive experience with streptomycin in wound infections showed that this agent is effective only as an adjunct to adequate surgery, and differs in no way from other chemotherapeutic agents with regard to its place in the surgical management of these conditions.

7. In enteric infections caused by specific, streptomycin-susceptible organisms, the results of treatment are likely to be impressive. In nonspecific ulcerative colitis no substantial benefits have been demonstrated.

8. In this experience, streptomycin in peritonitis did not produce dramatic results.

9. In bacteriemia due to streptomycin-sensitive organisms, highly impressive results were obtained. Essential to success, however, is eradication of the focus by surgical means when necessary.

10. Experience with tuberculosis was too small to permit definitive statements, but on the basis of the striking improvement that followed the use of the drug in a few of the cases, more intensive studies are warranted.

11. It is doubtful whether streptomycin therapy is of any value in brucellosis, except possibly in the acute phase of the disease.

12. In nontuberculous meningitis, due to sensitive organisms, streptomycin is a valuable therapeutic agent.

13. In typhoid fever, streptomycin would seem highly effective in the acute state, but after localization has occurred, the beneficial effects were much less evident.

14. In tularemia, streptomycin appeared to be the most effective chemotherapeutic agent presently available.

15. In other infections in this series, the experience was too small to permit conclusive statements concerning the therapeutic usefulness of streptomycin. It is noteworthy, however, that no striking results were obtained in those cases which are commonly considered surgical infections.

16. Vestibular disturbance was the only serious complication to streptomycin therapy, and is the only one presently considered to be an indication for termination of therapy.

BLOOD LOSS IN OPERATIONS: A STATISTICAL COMPARISON OF LOSSES AS DETERMINED BY THE GRAVIMETRIC AND COLORIMETRIC METHODS

IVAN D. BARONOFSKY, M.D.,* ALAN E. TRELOAR, PH.D., AND OWEN H. WANGENSTEEN, M.D., MINNEAPOLIS, MINN.

(From the Departments of Surgery and Biostatistics of the Medical School of the University of Minnesota)

THE replacement of blood lost during surgical procedures by either whole blood or plasma has become standard practice in the various surgical clinics. Quantitative determination of the blood loss is far preferable to purely subjective estimation, for the errors of personal judgment may reach to dangerous levels. This is particularly the case with the older substandard-risk patient who tolerates large blood loss poorly and who also cannot well withstand plethora induced as a result of overreplacement of blood lost in extensive surgical procedures. The best therapy in such patients is replacement both in kind and amount of the fluid lost.

A practical method which permits the surgeon to determine the extent of the blood loss with adequate accuracy while the operation is in progress is highly desirable. Since the advent of newer anesthetic procedures and drugs and increased emphasis on meeting the preoperative nutritional requirements of the patient has made possible more formidable and lengthy surgical procedures, concurrent replacement of blood loss assumes added significance as a factor contributing to success of those procedures.

QUANTITATIVE METHODS FOR BLOOD LOSS DETERMINATION

Various methods have been suggested from time to time for determination of blood lost during surgery. Gatch and Little[1] introduced the acid-hematin method in 1924. This involves washing all the sponges, linen, and instruments free of blood, then adding hydrochloric acid to those washings to make a 0.1 N solution. The acid-hematin preparation thus formed is then compared colorimetrically with a sample of acid-hematin prepared from the blood of the patient before surgery. These authors considered the blood loss so determined should be regarded as a minimum, for the chief error lies in inability to recover all the hemoglobin by washing. The error was stated to be at least 5 per cent. More recent methods have used modifications of this procedure, some introducing the photoelectric colorimeter.[2-5]

This entire determination must of necessity be accomplished after the surgery has been completed. Any replacement of blood or plasma that takes place during the operation must be done either as a matter of routine (that is,

Supported by grants from the graduate school, the Citizens Aid Society and the Augustus L. Searle Fund for Surgical Research.

Received for publication, Jan. 24, 1946.

*National Cancer Trainee.

during certain lengthy procedures a specified quantity of blood is automatically started) or on call from the surgeon whose estimate of blood loss determines the replacement. It has been shown that such estimations may be grossly inaccurate.[6]

It has been pointed out by Coller, Crook, and Iob[7] that there is no correlation between the amount of blood lost and changes in hematocrit, hemoglobin, and plasma protein concentrations before and after operations, and that the patient is benefited most when the blood is replaced as the loss occurs. In procedures such as transurethral resection, it may be practical to use the acid-hematin method to determine the blood loss at any juncture during the operation because the blood is washed directly into a container. However, this is an exceptional situation; it is not normally possible to measure blood loss during the operative procedure by the acid-hematin method.

One of us[8] pointed out in 1942 the importance of blood replacement during surgery and described the method in use at the University of Minnesota Hospitals to facilitate that replacement in the proper amount. This method is based very simply on the use of dry sponges for collecting blood lost during operation. The circulating nurse in the operating room weighs the used sponges during the course of the operation with sufficient frequency that evaporation from them does not become an item of importance. This procedure permits the surgeon to know the extent of the loss at any stage of the operation. In operations within serous or pleural lined cavities there is some absorption by the sponges of serous fluid which has a protein content of from 2 to 4 Gm. per cent. This fluid, which is replaceable, is accounted for in the gravimetric method along with the blood. The complete gain in weight of the sponges is treated as blood loss, each gram being considered as 1 c.c.

It might seem that the use of dry sponges would impose a serious handicap on the surgeon. Experience suggests definitely that it does not. Moist sponge packs are employed regularly to cover the intestine to keep fibrin formation on the bowel at a minimum; these sponges are not weighed.

THE PRESENT STUDY

The objective of this investigation has been twofold. First, it has seemed desirable to make a comparison of blood loss as measured by the gravimetric method and the loss as computed from the acid-hematin technique. In addition, an effort has been made to assemble blood loss data for representative surgical procedures as encountered in the University of Minnesota Hospitals, using the gravimetric method.

METHOD OF INVESTIGATION

Gravimetric.—A weighing scale (Fig. 1) accurate to 1 Gm. increments was used in this procedure. Dry sponges are used routinely during operation. These do not have to be weighed before each operation because they are remarkably uniform in weight and come from the autoclave at a constant level of dryness.* The sponges were weighed by a circulating nurse immediately

*Sponges used in this study and their weights are as follows: Curity x-ray 4 by 8 cm., 6 Gm. Special sponges, 90 by 10 cm., 14 Gm. Ring sponges, 28 Gm.

after use to reduce evaporation losses to a minimum. No correction was attempted for the slight departure from unity of the specific gravity of blood; each gram was considered as 1 c.c.

Colorimetric.—The sponges used during operation were washed and the colorimetric determinations made postoperatively. The method employed was a modification of the Gatch-Little technique differing in that we used the Evelyn colorimeter in determining the milligrams hemoglobin in an acid-hematin mixture. The blood-soaked sponges are extracted with tap water and the

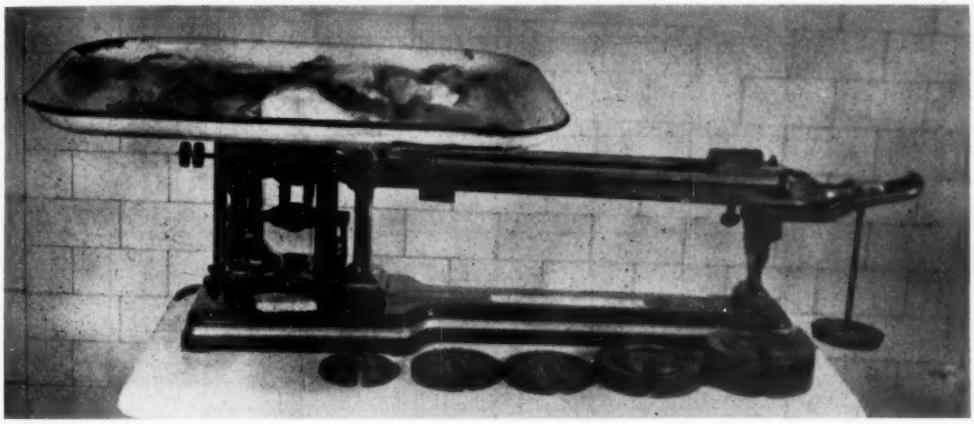

Fig. 1.—Use of the weighing scale in determining blood loss during operation. At any juncture, the surgeon may know how much blood has been lost. The surgeon must, of course, employ dry sponges. This scale will weigh to an accuracy of 1 Gm.

amount of hemoglobin in a sample of the pooled washings is then determined by interpolating a photoelectric colorimeter reading of the sample in a previously prepared chart. The total amount of blood lost is then computed by the formula:

$$100\ \frac{(\text{Mg. Hb. in sample}) \times (\text{Total volume of washings})}{\text{Patient's preoperative Hb.}}\ \text{c.c.}$$

RESULTS

Comparison of the Gravimetric and Colorimetric Determinations of Blood Loss.—Twenty-one surgical procedures were selected arbitrarily for this study. The basic data are summarized in Table I. It will be noted that the majority of the operations were performed within serous or pleural-lined cavities.

The close correlation between the blood loss values yielded by the two methods is shown graphically in Fig. 2 where each of the twenty-one dots represents a pair of determinations. The continuous diagonal line in Fig. 2 denotes equal values for the gravimetric and colorimetric methods; dots above this line designate cases wherein the colorimetric value was higher, while those below the line show a higher gravimetric value. The horizontal (or vertical) distance from each dot to the diagonal equality line defines the difference between the gravimetric and colorimetric determinations for each case.

It is quite apparent from Fig. 2 that higher colorimetric values are few in number, are small in margin of difference from the gravimetric result, and are concentrated in the low blood loss region. Sixteen of the twenty-one differences show an excess for the gravimetric measurement, as would normally be expected. In general, these differences increase slightly in magnitude as the blood loss increases. However, the agreement as a whole is remarkably close.

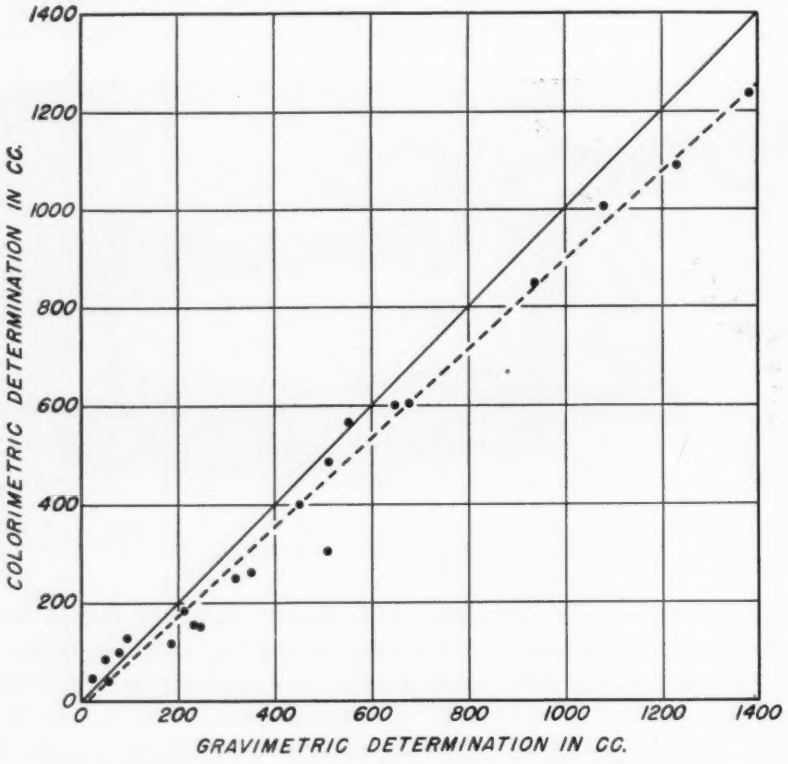

Fig. 2.—Relationship between gravimetric and colorimetric determinations of blood loss. Continuous diagonal line denotes identical values for the determinations. Interrupted line defines the average colorimetric value for each gravimetric determination.

The interrupted line in Fig. 2 indicates the "most likely" or expected average colorimetric value for each gravimetric value. The clustering of the dots above the line* indicates clearly that a straight line average relationship exists between the two methods. The difference between the continuous line and the interrupted line, therefore, portrays the average departure from equality of the two determinations. At low blood losses the difference is quite negligible for practical purposes. Even at high blood loss levels, the differences are not very large.

For all blood losses the colorimetric value, on the average, is very close to being 10 per cent less than the gravimetric value. Since losses in the process

*The equation for this line, as computed from the observed values is

$$C = 19.4 + 1.086G$$

where C = colorimetric and G = gravimetric value. The correlation coefficient for the association is + 0.9905.

TABLE I. SHOWING COMPARISON OF GRAVIMETRIC AND COLORIMETRIC DETERMINATION OF BLOOD LOSS

INITIALS	HOSPITAL NUMBER	SEX	OPERATION	PRE-OP. HB.	BLOOD LOSS		DIFFERENCE
					COLORIMETRIC	GRAVIMETRIC	
E. K.	744309	F	Gastroenterostomy	13.05	115	187	+ 72
A. E.	721039	F	Cholecystectomy	12.00	154	247	+ 93
A. G.	744986	M	Subtotal gastrectomy	14.00	305	509	+204
J. O.	684731	M	Colon resection	15.60	400	450	+ 50
L. S.	701020	F	Cholecystectomy	14.00	100	79	- 21
G. S.	743507	M	Subtotal gastrectomy	11.40	1,240	1,385	+145
W. B.	736170	M	Cholecystectomy	13.45	605	678	+ 73
S. D.	746017	M	Pneumonectomy	13.05	600	648	+ 48
F. D.	746167	M	Subtotal gastrectomy	12.85	1,006	1,078	+ 72
H. H.	636960	F	Cholecystectomy and choledochostomy	11.30	1,090	1,231	+141
S. E.	170101	M	Diaphragmatic hernia	13.10	131	93	- 38
A. P.	744149	M	Gastroenterostomy	12.05	182	210	+ 28
B. S.	746274	M	Subtotal gastrectomy and colon resection	13.00	850	936	+ 86
G. O.	744513	M	Splenectomy	13.35	40	58	+ 18
D. C.	755585	F	Repair of ventral hernia	14.90	83	48	- 35
S. F.	750187	F	Gastroenterostomy	13.10	48	22	- 26
H. W.	755258	M	Subtotal gastrectomy	13.90	488	511	+ 23
G. J.	756362	M	Radical mastectomy	11.80	568	550	- 18
M. S.	756210	F	Subtotal gastrectomy	11.70	261	351	+ 90
M. W.	756379	F	Choledochostomy	12.60	156	233	+ 77
S. G.	756415	M	Subtotal gastrectomy	14.90	250	319	+ 69
	Total				8,672	9,823	1,151

of extraction of blood from the sponges reduce the colorimetric value below what it should be, it is clear that the gravimetric determination cannot be much in excess of the true blood loss. The increment of serous fluid other than blood in the gravimetric determination is obviously only a very small proportion of the total.

Blood Loss in Operations of Various Kinds.—The blood losses during consecutive surgical procedures, as determined by the gravimetric method, will now be reviewed.* During appendectomy, blood loss was minimal and averaged 25.8 c.c. (Table II). Hernia and gall bladder procedures averaged 82.9 and 179.4 c.c., respectively (Tables III and IV). Operations on the large bowel do not entail high blood losses (121.5 c.c., see Table V). This may be presaged because the major blood supply to the intestine is directly visible and easily approached.

Comparison of the data obtained from subtotal gastrectomy for ulcer and carcinoma (499.8 and 455.6 c.c., respectively, see Tables VI and VII) shows

TABLE II. BLOOD LOSS IN APPENDECTOMY (GRAVIMETRIC)

INITIALS	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
H. B.	729569	Appendectomy	35.0
B. Y.	752284	Appendectomy	34.0
D. R.	756865	Appendectomy	25.0
A. W.	757055	Appendectomy	34.0
H. C.	757079	Appendectomy	5.0
	Average		25.8

*These operations were consecutive and were conducted between Nov. 9, 1944, to Aug. 1, 1945, inclusive.

an unimportant difference. These findings are consistent with those of Oppenheim and associates.[6] Three of the patients in the ulcer group (W. P., F. S., F. W., in Table VI) had blood losses over one liter. A review of the operative records indicated that F. W. had a prepyloric ulcer which was surrounded by very numerous adhesive bands. It was in dissecting these adhesions that most of the blood loss occurred. A study of the record of W. P. disclosed that this individual was very corpulent (89 kg.); intraperitoneal fat was at a maximum, and it was in dissecting and clearing the fat so that the organs could become visible that the loss occurred. A study of the record of F. S. revealed that this man had a gastrojejunal ulcer attendant on a simple gastrojejunostomy done years previously. This proved to be very adherent and in dissecting the

TABLE III. BLOOD LOSS IN INGUINAL HERNIOPLASTY (GRAVIMETRIC)

INITIAL	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
M. F.	755310	Bilateral hernioplasty	156.0
H. B.	753153	Hernia and excision of spermatocele	95.0
F. Z.	749568	Hernioplasty	263.0
D. S.	713875	Hernioplasty	14.0
R. K.	756366	Hernioplasty	65.0
H. W.	653465	Hernioplasty	1.0
R. R.	756462	Hernioplasty	105.0
G. T.	756485	Hernioplasty	18.0
P. S.	755538	Hernioplasty	25.0
L. K.	756775	Bilateral hernioplasty	87.0
	Average		82.9

TABLE IV. BLOOD LOSS IN CHOLECYSTECTOMY (GRAVIMETRIC)

INITIALS	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
H. H.	741352	Cholecystectomy	159.0
K. S.	743772	Cholecystectomy	56.0
L. G.	750925	Cholecystectomy	61.0
E. B.	750397	Cholecystectomy	135.0
M. H.	753158	Cholecystectomy and appendix	186.0
S. S.	736158	Cholecystectomy	137.0
A. C.	755574	Cholecystectomy and appendix	357.0
M. H.	755676	Cholecystectomy	193.0
H. S.	755650	Cholecystectomy and appendix	158.0
M. G.	756026	Cholecystectomy	220.0
S. R.	755741	Cholecystectomy and appendix	132.0
	Average		179.4

TABLE V. BLOOD LOSS IN COLON RESECTION (GRAVIMETRIC)

INITIALS	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
B. V.	752862	Colon resection and end-to-end transverse colocolostomy	95.0
J. N.	752927	Colon resection—end-to-end rectosigmoidostomy	119.0
C. R.	667015	Colon resection—end-to-end ileocolostomy	48.0
C. M.	752730	Right colon resection—end-to-end ileocolostomy	149.0
L. M.	753582	Right colon resection—end-to-end ileocolostomy	98.0
F. P.	753425	Left colon resection—end-to-end rectosigmoidostomy	167.0
C. L.	684357	Colon resection, left—end-to-end colocolostomy	303.0
A. M.	756841	Right colectomy—end-to-end ileocolostomy	72.0
I. M.	756823	Right colectomy—end-to-end ileocolostomy	50.0
F. L.	757054	Right colectomy—end-to-end ileocolostomy	114.0
	Average		121.5

adhesions off so that both the gastric resection and an end-to-end small bowel anastomosis could be done, there was a great deal of blood lost.

Thyroidectomy entailed an average blood loss of 405.6 c.c. which is fairly high (Table VIII). However, examination of the records shows that diffusely

TABLE VI. BLOOD LOSS IN SUBTOTAL GASTRECTOMY FOR ULCER (GRAVIMETRIC)

INITIALS	HOSPITAL NUMBER	OPERATION	BLOOD LOSS	AGE (YR.)	WEIGHT (KG.)
R. B.	747612	Subtotal gastrectomy	461	43	81.0
C. R.	747669	Subtotal gastrectomy	807	52	61.0
M. P.	624209	Subtotal gastrectomy	176	74	36.2
Z. L.	747691	Subtotal gastrectomy	437	46	41.4
G. W.	630013	Subtotal gastrectomy	312	75	82.3
M. S.	722831	Subtotal gastrectomy	449	34	68.4
M. S.	747211	Subtotal gastrectomy	300	34	64.0
B. H.	693845	Subtotal gastrectomy	252	54	75.8
C. S.	747664	Subtotal gastrectomy	253	59	61.2
W. P.	749484	Subtotal gastrectomy	1,202	39	89.0
T. D.	677891	Subtotal gastrectomy	319	32	71.0
M. R.	747886	Subtotal gastrectomy	269	62	64.0
F. S.	749978	Subtotal gastrectomy	1,044	56	73.3
A. B.	749858	Subtotal gastrectomy	685	33	72.7
R. C.	749426	Subtotal gastrectomy	447	36	68.0
H. S.	750649	Subtotal gastrectomy	602	41	74.6
B. J.	750884	Subtotal gastrectomy	226	45	65.8
G. H.	753763	Subtotal gastrectomy	298	37	51.6
A. B.	753728	Subtotal gastrectomy	373	34	53.2
J. U.	705853	Subtotal gastrectomy	350	70	50.8
L. T.	755242	Subtotal gastrectomy	441	43	59.8
V. B.	755244	Subtotal gastrectomy	438	55	48.8
F. W.	752074	Subtotal gastrectomy	1,432	49	85.2
A. P.	750800	Subtotal gastrectomy	478	63	48.6
C. A.	750017	Subtotal gastrectomy	446	53	71.8
	Average		499.8		

TABLE VII. BLOOD LOSS IN SUBTOTAL RESECTION FOR CARCINOMA (GRAVIMETRIC)

INITIALS	HOSPITAL NUMBER	OPERATION	BLOOD LOSS	AGE (YR.)	WEIGHT (KG.)
I. D.	753168	Subtotal gastrectomy	226	59	51.4
H. H.	752498	Subtotal gastrectomy	448	41	53.6
H. H.	753085	Subtotal gastrectomy	487	61	50.4
J. A.	752527	Subtotal gastrectomy	371	66	60.0
G. A.	752782	Subtotal gastrectomy	341	78	54.0
W. D.	752784	Subtotal gastrectomy	706	62	66.2
A. C.	752701	Subtotal gastrectomy	427	38	68.4
J. C.	745161	Subtotal gastrectomy	259	65	61.0
F. H.	755016	Subtotal gastrectomy	579	68	63.2
J. C.	753251	Subtotal gastrectomy	580	58	79.6
A. K.	753467	Subtotal gastrectomy	980	52	65.8
R.	749545	Subtotal gastrectomy	219	52	61.6
H. R.	749719	Subtotal gastrectomy	155	60	71.8
W. S.	750115	Subtotal gastrectomy	464	68	58.2
J. D.	668827	Subtotal gastrectomy	935	66	63.0
G. I.	747255	Subtotal gastrectomy	255	50	54.0
H. W.	753967	Subtotal gastrectomy	176	65	59.0
C. L.	756857	Subtotal gastrectomy	659	64	72.4
C. M.	753895	Subtotal gastrectomy	440	62	55.6
E. R.	756969	Subtotal gastrectomy	695	46	84.2
A. P.	711195	Subtotal gastrectomy	385	70	51.0
M. S.	756210	Subtotal gastrectomy	351	75	59.5
O. B.	755768	Subtotal gastrectomy	451	57	77.4
M. B.	753999	Subtotal gastrectomy	447	28	34.4
W. E.	755088	Subtotal gastrectomy	354	64	64.0
	Average		455.6		

enlarged goiters in patients with high initial basal metabolic rates provide most of the bleeding. The average blood loss for the diffusely enlarged glands was 668 c.c. while that for the nodular gland was 206 c.c.

TABLE VIII. BLOOD LOSS IN SUBTOTAL THYROIDECTOMY (GRAVIMETRIC)

INITIALS	HOSPITAL NUMBER	AGE (YR.)	OPERATION	BLOOD LOSS	B. M. R. ON ENTRY	NODULAR OR DIFFUSE GLAND	PER CENT RESECTED
J. H.	750144	57	Subtotal thyroidectomy	144	+ 30	Nodular	90
R. W.	750394	58	Subtotal thyroidectomy	609	+ 75	Diffuse	99
I. H.	753666	52	Subtotal thyroidectomy	888	+111	Diffuse	99
E. A.	753253	61	Subtotal thyroidectomy	578	+ 80	Diffuse	95
L. R.	753267	67	Subtotal thyroidectomy	212	+ 65	Nodular	95
M. L.	672614	48	Subtotal thyroidectomy	354	B. M. R. not done	Cancer	50
M. R.	756181	41	Subtotal thyroidectomy	597	+ 97	Diffuse	95
M. A.	756620	44	Subtotal thyroidectomy	228	+ 30	Nodular	90
M. S.	637953	47	Subtotal thyroidectomy	100	+ 39	Nodular	90
H. G.	656813	46	Subtotal thyroidectomy	346	+ 37	Nodular	80
	Average			405.6			
	Average for the diffusely enlarged gland			668.0			
	Average for the nodular goiter			206.0			

TABLE IX. BLOOD LOSS IN RADICAL MASTECTOMY (GRAVIMETRIC)

INITIAL	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
L. E.	755438	Radical mastectomy	310
C. H.	749720	Radical mastectomy	695
A. J.	756247	Radical mastectomy	406
N. R.	750238	Radical mastectomy	196
G. J.	756362	Radical mastectomy	550
L. E.	755438	Radical mastectomy	310
A. G.	756144	Radical mastectomy	338
I. G.	756314	Radical mastectomy	350
O. W.	756118	Radical mastectomy	344
A. J.	756589	Radical mastectomy	605
Average			415.4

TABLE X. BLOOD LOSS IN PNEUMONECTOMY AND LOBECTOMY (GRAVIMETRIC)

INITIAL	HOSPITAL NUMBER	OPERATION	BLOOD LOSS
F. R.	752275	Pneumonectomy for carcinoma	1,457
O. F.	753104	Pneumonectomy for carcinoma	1,444
A. M.	747663	Pneumonectomy for carcinoma	1,154
B. J.	747501	Pneumonectomy for carcinoma	2,124
J. M.	749308	Pneumonectomy for carcinoma	1,490
L. K.	755181	Left pneumonectomy for bronchiectasis	691
A. A.	753762	Lobectomy (right lower lobe and right middle lobe) for bronchiectasis	682
C. K.	698525	Right lower lobe and right middle lobe lobectomy for bronchiectasis	1,755
L. P.	617665	Right upper lobectomy for bronchiectasis	1,470
H. K.	749320	Right lower lobe lobectomy for bronchiectasis	1,492
I. S.	740694	Right lower lobe lobectomy for bronchiectasis	475
M. B.	749302	Left lower lobe lobectomy for bronchiectasis	995
M. B.	750600	Left pneumonectomy for bronchiectasis	2,983
P. S.	752302	Left pneumonectomy for bronchiectasis	1,375
	Total average		1,399.0
	Carcinoma average		1,534.0
	Bronchiectasis average		1,324.3

The average loss during radical mastectomy was 415.4 c.c. (Table IX). Pneumonectomy and lobectomy proved to be procedures during which the blood loss was very high (Table X). This is consistent again with the findings of others. The average for these procedures was 1,399 c.c. There was no significant difference between the average obtained for pneumonectomy for carcinoma (1,543 c.c.) and that for pneumonectomy or lobectomy for bronchiectasis (1,324 c.c.). As pointed out previously,[6] there is a good deal of blood lost in making the necessarily long incision.

The figures presented in the foregoing section serve as a guide to the average blood loss of various surgical procedures. In each operation of any magnitude, a 5 per cent solution of glucose is allowed to run slowly into one of the patient's leg or ankle veins from the outset. For blood losses of 500 c.c. or less, an equivalent amount of plasma is usually adequate. However, it is best to replace blood losses in excess of 500 c.c. with an equivalent amount of blood. De Gowin and Hardin[9] suggested that an alkaline urine obtained by the intravenous administration of sodium bicarbonate solution (250 c.c. of 5 per cent solution) when administering blood may diminish the formation of albuminous casts in the renal tubules attending hemolytic reactions. The clinical evidence on this point, however, is not conclusive.

SUMMARY AND CONCLUSIONS

Gravimetric determination of gain in sponge weight provides a reliable estimate of blood loss in surgical procedures. The extent of such blood loss may be determined as the procedure is progressing without any interference to the surgeon, thus allowing almost concurrent replacement. A reduction of the sponge weight gain by somewhat less than 10 per cent provides an acceptable average correction for other fluids taken up by the sponges; however, replacement of such loss by plasma or blood may be as desirable as for the blood itself. The blood loss in various surgical procedures at the University Hospital is presented.

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CHEMICAL ALTERATIONS OCCURRING IN THE SURGICAL PATIENT AND THEIR INTERPRETATIONS

WILLIAM E. ABBOTT, M.D.,* DETROIT, MICH.
(From the Department of Surgery, Wayne University College of Medicine)

THE problem of maintaining a sick patient in a state of good nutrition and in water balance is a complex one. Many studies have appeared recently on the alterations of fluid, protein, and electrolytes in various diseased conditions, and it is the purpose of this paper to point out some of the disputed problems and to clarify them if possible.

Accurate chemical methods are helpful in determining the state of electrolyte balance, hydration, or nutrition of sick and injured individuals, but unfortunately most of these determinations are quite complex and time consuming so many workers[1-12] have relied on the hemoglobin, cell volume (hematocrit), specific gravity of whole blood and plasma, and the plasma chloride, protein, or albumin concentration. Such determinations can be of great assistance if properly evaluated, but unfortunately may also be misleading and should not be given preference over the patient's history and physical findings.

It should be kept in mind that a low or normal plasma sodium, protein, or chloride concentration can be encountered when a state of dehydration or overhydration exists. It has been stated that the hematocrit may serve as a guide,[1, 2, 5, 6] but here again so-called high, normal, or low values may be noted in the apparently normal individual[13] or when dehydration[14] or shock[15] is present. Such determinations may at times indicate directional changes in hydration but they cannot be employed as a quantitative measure of it.

Recently, in determining the hematocrit values in fifty-nine apparently normal volunteer male subjects[13] it was found that the values ranged between 41.8 and 52.4, with a mean hematocrit value of 48.2. Thus, some apparently normal people show values which by the "clinical rules" would be considered abnormal. Varying degrees of anemia may also exist in the sick patient either because of a pre-existing anemia or because of destruction of red blood cells resulting from the injury or illness. It is quite possible then to have a hematocrit of 35 increase to 45 following an injury, but because it appeared to be normal, therapy might be withheld if clinical rules were strictly adhered to.

Several years ago it was shown that various chemical determinations may be normal in cases with intestinal obstruction,[14] carcinoma of the stomach, or pyloric stenosis,[16] and yet the patient may be in a state of malnutrition or dehydration. Marriott[17] earlier emphasized the same fact and Lyons[18] more recently reported results on patients with infection who may also show hemoglobin and plasma protein concentrations which are not indicative of the true

Read at the meeting of the Western Surgical Association, December, 1945.
Received for publication, Jan. 28, 1946.
*Now at Harper Hospital, Detroit, Mich.

TABLE I. THE DISCREPANCY BETWEEN THE PLASMA PROTEIN CONCENTRATION AND TOTAL CIRCULATING PLASMA PROTEINS

CASE	DIAGNOSIS	MEASURED PLASMA VOLUME (C.C.)	EXPECTED PLASMA VOLUME (C.C.)*	PLASMA VOLUME (PER CENT OF NORMAL)	PER CENT CELL VOLUME (HEMATOCRIT)	PLASMA PROTEIN CONCENTRATION (GM. PER 100 C.C.)	PLASMA PROTEIN CONCENTRATION (PER CENT OF NORMAL) †	TOTAL CIRCULATING PLASMA PROTEINS (GM.)	EXPECTED TOTAL CIRCULATING PLASMA PROTEINS (GM.)	TOTAL CIRCULATING PLASMA PROTEIN (PER CENT OF NORMAL)
1	Carcinoma of stomach	1,640	2,500	66	47	6.40	91	105	175	60
2	Carcinoma of stomach	1,990	2,690	74	38	5.85	84	116	188	62
3	Carcinoma of esophagus	1,870	2,900	64	41	5.46	78	102	203	50
4	Carcinoma of stomach	2,100	2,710	77	44	6.46	92	136	190	72
5	Pyloric stenosis due to ulcer	1,480	2,040	73	37	6.15	88	91	143	64
6	Pyloric stenosis due to ulcer	2,140	2,600	82	40	5.92	85	127	183	69

*Calculated from body surface area.

†Seven grams per 100 c.c. was used as the normal plasma protein concentration.

Since the normal values for these cases were calculated by employing the surface area there may be some question of their validity. However, it should be remembered that the normal plasma volumes were calculated from the surface area by employing the patient's weight in his malnourished state and since these patients lost twenty to forty pounds during their illness, the patient's actual normal plasma volume would probably be much greater. For example, the second patient lost thirty-five pounds, and if his normal weight had been employed in determining the surface area the estimated plasma volume would be approximately 3,100 c.c. and the per cent of normal total circulating proteins would be 53 instead of 62 per cent. Similarily, the estimated normal plasma volume for Case 6 is listed as 2,600 c.c., but if the patient's normal weight had been employed in the calculation, the expected plasma volume would have been 2,950 c.c. and the total circulating plasma protein 206 Gm. instead of 183 Gm.

existing state. Other studies[19, 20] have also stressed the importance of volume alterations as well as changes in the blood concentration. While at times the plasma volume determination may prove to be a valuable adjunct in the care of patients, it too has its limitations.[13] It has been shown[13, 21] that an estimated normal plasma volume calculated from the surface area, height, or weight may be in considerable error.

In Table I are shown the results of six previously reported cases.[16] The hematocrit and the plasma protein concentration do not appear markedly lowered. It should be noted, however, that the plasma volume is well below the expected normal range, and that there is a definite reduction in the red cell mass and total circulating proteins which is masked by dehydration. Thus, if the plasma volume were restored to its pre-existing level by the administration of salt solutions, without the addition of protein, there would be a precipitous fall in the plasma protein concentration. Experimental studies[22] have demonstrated that under certain conditions the plasma protein concentration may remain normal or fall slightly with a simultaneous increase in the amount of total circulating plasma protein.

In Table II is illustrated the approximate change which would occur in the aforementioned patients if a normal total blood volume or a normal plasma volume were restored without the addition of red blood cells or plasma protein. It is felt that since a precipitous fall in the plasma protein concentration may occur in hemorrhaging or malnourished patients who cannot mobilize additional plasma protein, solutions containing sodium salts should be temporarily withheld or given very cautiously following major surgical procedures.

A significant fall in the plasma protein concentration postoperatively has been shown to occur[23, 24] in some patients, but in nondepleted or nutritionally normal individuals only a slight change in concentration results even though the extracellular fluid volume is increased, because an adequate amount of protein can be mobilized.[25, 26]

TABLE II. CHANGES WHICH WOULD OCCUR IN MALNOURISHED PATIENTS IF THE PLASMA VOLUMES WERE RESTORED TO NORMAL BY THE ADDITION OF FLUID CONTAINING SODIUM SALTS

CASE	DETERMINED HEMATOCRIT	HEMATOCRIT IF PLASMA VOLUME WERE RESTORED TO NORMAL*	HEMATOCRIT IF TOTAL BLOOD VOLUME WERE RESTORED TO NORMAL*	DETERMINED PLASMA PROTEIN CONCENTRATION (GM. PER 100 C.C.)	PLASMA PROTEIN CONCENTRATION IF PLASMA VOLUME WERE RESTORED TO NORMAL*	PLASMA PROTEIN CONCENTRATION IF BLOOD VOLUME WERE RESTORED TO NORMAL*
1	47	37	32	6.40	4.20	3.40
2	38	31	33	5.85	4.31	3.12
3	41	31	25	5.46	3.52	2.58
4	44	38	33	6.46	5.02	4.15
5	37	30	23	6.15	4.46	3.21
6	40	35	30	5.92	4.88	3.80

*Calculated on the basis of a return to a normal volume without the addition of red blood cells or plasma protein.

Prolonged anesthesia,[27] shock,[28] anoxia[29] and trauma or injury to the body[15, 30, 31] may effect the elimination of various solutes and water by the kidneys. The ability to eliminate sodium chloride postoperatively may, therefore, in some instances be impaired. Water and salt retention may also occur in alcoholics[32] and in patients with pneumonia,[33, 34] with a resulting increase in the extracellular fluid volume.[35] It has also been noted in patients convalescing from heart failure[36] and in subjects with adrenal dysfunction.[37] In the seriously ill surgical patient who is given 1 to 2 L. of a salt solution daily, the body may have forced upon it 9 to 18 Gm. of sodium chloride. Normally on such an intake of salt almost all of it would be excreted by the kidneys but when such is not feasible it leads to an increased extracellular fluid volume. Postoperative salt intolerance has been well emphasized[38, 39] and it has been demonstrated also[40] that when large amounts of saline are given, sizable quantities of salt may be retained following operations for carcinoma of the colon. Pulmonary, cerebral, or gastrointestinal edema may thus result with serious consequences.

The undesirable effect of large amounts of a saline solution were well reviewed by Trout[41] and later by Matas.[42] They pointed out the dangers of even a normal salt intake when the kidneys were not functioning properly and presented evidence to show that salt may actually cause renal damage and anuria when given to patients postoperatively.

The excessive administration or retention of water and salt, of course, are not the only factors of importance in the production of edema, but as others have shown[36, 43, 44] many factors must be considered.

In the studies of Jones, Eaton, and White,[43] excessive nitrogen catabolism or nitrogen starvation and infection seemed to be the most important factors causing edema in surgical patients, but only when sufficient fluid and salt were available to pass into the affected area.

The formation of edema, either localized or generalized, usually results when one or more of the following causes are present: (1) protein depletion (a reduction in the colloid osmotic pressure especially due to a loss of plasma albumin), (2) increased hydrostatic or filtration pressure, (3) increased capillary permeability (due to anoxia, inflammation, physical agents, or drugs), (4) increased osmotic pressure of the interstitial fluid or decreased tissue elasticity, (5) a temporary or permanent failure of the kidneys to excrete water or eliminate salt due to kidney or endocrine dysfunction, (6) obstruction to the lymphatics, and (7) the overadministration of isotonic or hypertonic salt solution with a resulting shift of intracellular fluid to the extracellular phase. The excretion rate following loading with several different solutions is shown in Figs. 1 and 2. Similar results[39, 45] were noted by other workers. In the recent work of Coller, Iob, Vaughan, Kalder, and Moyer,[39] they emphasized the derangement of the body fluid compartments which may result from improper fluid administration. As they pointed out, isotonic salt (0.9 per cent) solutions are not desirable because a greater per cent of the ingested water is eliminated than salt, leaving a hypertonic extracellular phase which is then

corrected if no other water is given by a withdrawal of water from the cell. Winkler, Elkinton, Hopper, and Hoff[46] have shown that extreme water depletion can occur within the cell when the extracellular fluid is hypertonic and they believe that under such circumstances death usually results from respiratory failure while the cardiovascular system is little affected. It has also been shown[39] that large amounts of a half-strength isotonic salt solution (0.45 per cent) produced an opposite effect (that is, the accumulation of more

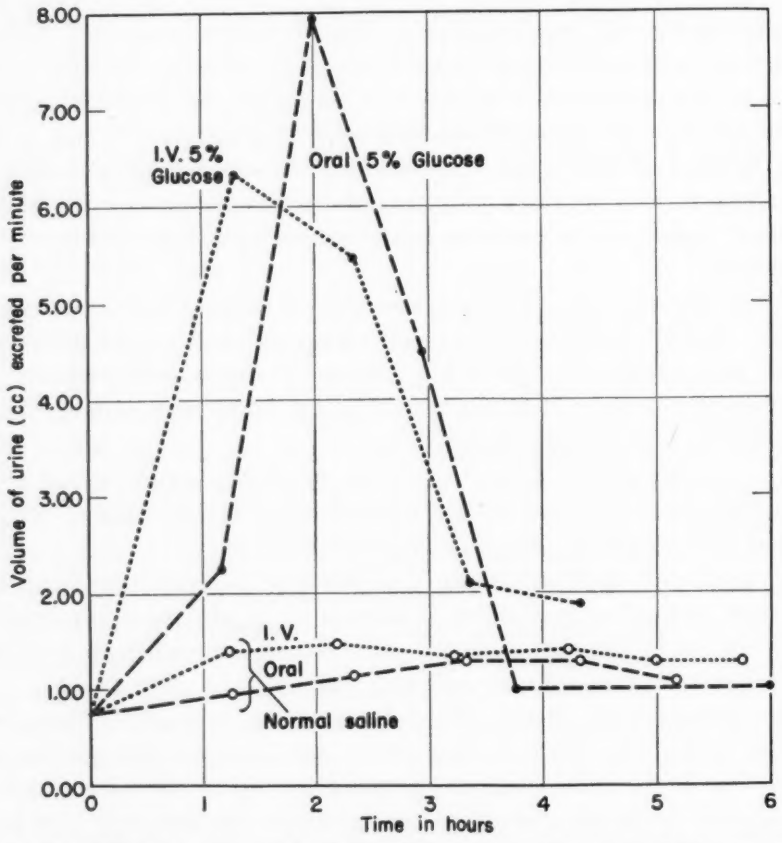

Fig. 1.—The difference in the rate of excretion between the oral and intravenous intake of 1,000 c.c. of 5 per cent Dextrose in distilled water and the oral and intravenous intake of 1,000 c.c. of normal saline solution.

water than salt), thus resulting in a hypotonic extracellular phase with a resulting intracellular shift of water. The shift of body fluid from one compartment to another because of changes in the amount and concentration of various electrolytes has also been well demonstrated by experimental studies.[47-51]

The most logical method available, at present, of estimating deficiencies in red cells, protein, salts, and fluid is by a careful history and physical examination and a correlation of the important findings with the laboratory data. The type of therapy becomes fairly obvious, regardless of the blood chemical determinations when one learns that the particular patient in question has lost

considerable weight, has consumed little food and fluids, has vomited frequently, or has noted bloody or tarry stools. The physical findings of a wrinkled, pale skin, dry-coated tongue, and sunken eyeballs with subnormal tension verify the impressions gained from a careful history.

Some recent publications have intimated that sodium chloride[6, 8, 9, 12, 52, 53] deficiencies or the state of hydration could be estimated from the plasma chloride concentration. However, experience has taught us that such reasoning is unsound, as was pointed out in 1928 by McIver and Gamble.[54] They have shown that a loss of bile and intestinal fluid may occur with a resulting reduction in the total amount of body electrolytes and fluid without appreciably

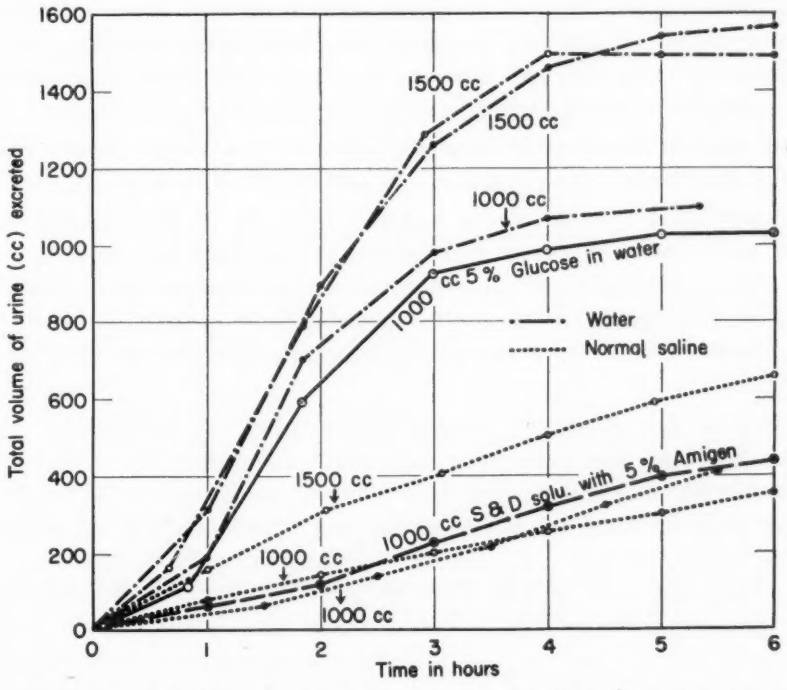

Fig. 2.—The amount of urine excreted following the oral ingestion of various solutions. (The figure near the excretion line shows the amount of fluid ingested at zero time.) The solution which is labeled S & D is a salt solution with a chemical make-up similar to plasma except that there is no protein present.

altering the plasma chloride or bicarbonate concentrations. Slightly elevated plasma chloride levels may occur following the ingestion of fairly large quantities of salt and may sometimes be encountered in acidosis resulting from an excessive loss of bicarbonate (such as upper intestinal and pancreatic fistula, some cases of diarrhea and starvation). High electrolyte values are not often encountered clinically but when they do occur, or if they persist, it is almost always a result of inadequate kidney function. Increases in the electrolyte concentration most frequently occur in dehydration and, of course, result because of a greater deficiency of water than salts.[47]

Normal or low plasma chloride or sodium concentrations are frequently encountered when dehydration is present,[10, 14] but such values may be obtained

also when studying overhydrated convalescent burned patients,[15, 31] or individuals with malnutrition edema. Therefore, such determinations should not be regarded as necessarily indicating the need of salt and water. For example, in Table III are presented the findings in a patient with postoperative malnutrition edema. At first this patient was given a physiologic solution of sodium chloride in an attempt to restore the plasma chloride concentration to normal, but when the patient's edema became severe and the chloride level showed little change, this therapy was discontinued. It was then obvious that the patient's extracellular fluid volume had increased greatly and the chloride concentration did not mirror the state of hydration. If one assumed that such an individual had a normal extracellular fluid volume of 15,000 c.c. with a chloride concentration of 106 meq. per liter, one could estimate that he should have approximately 1,590 meq. of chloride in the extracellular fluid compartment under normal circumstances. Since an increase above the normal of about 5,000 c.c. may be necessary in an adult before edema can be noticed clinically[54] and since the edema in this patient was quite marked, it was assumed that the extracellular fluid volume would equal somewhere in the vicinity of 22,000 c.c. By multiplying the determined chloride concentration (88 meq. per liter) by the aforementioned figure it can be seen that approximately 1,836 meq. of chloride were present. Thus, in this patient there apparently was an excess of chloride but because of a greater increase in water than in chloride the low leved was obtained.

This man was effectively treated by stopping the salt intake completely for four days and then permitting only small amounts of it. Since there had been a reduced caloric and protein intake because of anorexia, vomiting, and diarrhea, he was not given anything by mouth but received intravenously 75

TABLE III. POSTOPERATIVE MALUTRITION EDEMA IN A 60-YEAR-OLD MAN

DATE (1941)	TOTAL DAILY FLUID INTAKE (C.C.)	INTAKE OF SALT (GM. PER DAY)	URINARY OUTPUT (IN C.C.)	HEMATOCRIT	PLASMA PROTEINS (GM. PER 100 C.C.)	PLASMA CHLORIDES (MEQ. PER LITER)	APPROXIMATE TOTAL EXTRACELLULAR CHLORIDE (MEQ.)	REMARKS
4/16	3,000	18	820	43.0	6.95	104.0		Operation
4/28	3,880	18	700	34.0	6.30	96.0		Wound disruption
5/16	3,200	18	620	31.0	4.92	85.0		Edema
5/19	3,000	27	475	30.6	4.82	88.0	1936.0	Edema increased
5/20	3,600	0	1,270			94.0		
5/21	3,600	0	1,600	30.0	4.60	98.0		
5/22	3,600	0	2,150					
5/23	3,600	0	2,350					Edema free
5/24	2,700	6.3	1,750					
5/25	3,200	6.3	1,810	32.0	5.01	106.0	1590.0	
5/26	3,200	6.3	1,680					
5/30	–	–	1,240	35.0	5.64	104.0		Eating well
6/10	–	–	970	40.0	6.54			

to 90 Gm. of protein in the form of amino acids* and 210 to 250 Gm. of dextrose daily. The entire caloric intake, while not large, ranged between 1,200 to 1,300 calories per day. The patient was given parenteral feeding for ten days and during this time was in a positive nitrogen balance. The amount of urine excreted daily increased and the patient was visibly free from edema in seventy-two hours. The removal of the excess body water was thought to result from the high fluid and restricted salt intake, and the diuretic effect of urea (the latter being obtained from the intravenously administered casein hydrolysate). Parenteral therapy was discontinued and an adequate diet was then taken by mouth.

Plasma volumes and protein concentrations were obtained before and shortly after the ten days of parenteral feeding, and the results are shown in Table IV. By comparing the plasma protein concentration before and after therapy it would seem as though the plasma proteins were not increased, but by calculating the total circulating plasma protein level it can be seen that an increase of 27 per cent occurred.

TABLE IV. CHANGE IN TOTAL CIRCULATING PLASMA PROTEINS FOLLOWING PARENTERAL AMINO ACID THERAPY

DATE	PLASMA VOLUME (IN C.C.)	PLASMA PROTEIN CONCENTRATION (GM. PER 100 C.C.)	TOTAL CIRCULATING PLASMA PROTEIN (GM.)	PER CENT CHANGE IN TOTAL CIRCULATING PLASMA PROTEIN
5/17/41	2,300	5.06	117.8	
5/29/41	2,930	5.10	149.5	+27

In this case, and in other patients with malnutrition edema, as well as in convalescent burned patients[15] and animals,[22] it has been noted that edema will often disappear when the protein concentration remains low. Similar observations have been made by Schemm[56] on cardiac and nephrotic patients. Because of these findings and because edema may occur in patients with a relatively normal plasma protein concentration[43] and may not occur when the plasma protein concentration is below 5 Gm. per 100 c.c., it is therefore obvious that the amount of water and salt consumed is extremely important and plays a significant part in the formation of edema. In many such cases the plasma protein and albumin concentrations often increase gradually following a diuresis. This rise appears to be a result of the body getting rid of fluid rather than a cause of it.

In Table V is shown the course of another patient with a marked malnutrition edema. Because of edema of the gastrointestinal tract the patient was vomiting frequently and having ten to sixteen watery stools a day. An effective diuresis was obtained by the administration of citrated blood, plasma, and suitable diuretics (ammonium chloride and mercupurin), and by the restriction of salt. This led to relief of gastrointestinal symptoms. It can be seen from these results that the plasma protein concentration was not significantly altered before or during the diuresis.

*Supplied by Frederick Stearns & Company, Detroit, Mich.

TABLE V. RESPONSE OF A 28-YEAR-OLD WOMAN PATIENT WITH POSTOPERATIVE MALNUTRITION EDEMA TO BLOOD AND PLASMA INTRAVENOUSLY AND DIURETICS

DATE	ORAL INTAKE (IN C.C.)	BLOOD	PLASMA (C.C.)	URINE OUTPUT (IN C.C.)	HEMATOCRIT	PLASMA PROTEIN
3/4	475	1,000	300	6,200	36.0	3.54
3/5	675	(9 Gm. of ammonium		1,500	35.7	3.87
3/6	500	chloride given		2,400		
3/7	450	daily for 3 days)		1,200		
3/8	560	(2 c.c. mercupurin)	425	12,500	40-37	4.25-4.99
3/9	1,050			1,100	39.1	4.69
3/10	1,400			800		
3/11	1,135			1,500		
3/12	1,125	500	225	1,200	42.4	4.83
3/13	1,400			1,200		
3/14	1,745			1,900		
3/15	1,800	600		2,050		
3/16	1,620			2,000		
3/17	2,550	(2 c.c. mercupurin)		4,250		
3/18	2,175			1,400	45.0	5.34
3/19	1,750			1,300		
3/21	2,300			1,600		5.80
3/23					49.3	6.05
Total	22,710	2,100	950	44,100		

It has been stated[57] that death will rarely result from circulatory or renal insufficiency in cases of low intestinal obstruction because of alterations in body fluids. It has been accepted, however, that in pyloric or high intestinal obstruction a fatal outcome may frequently result from dehydration or an acid-base imbalance.[54, 57, 58, 59] In low obstructions it was assumed that the body fluid compartments were not greatly altered because various blood constituents (hematocrit, protein, chloride) were normal. As shown in Table VI, such determinations may often be within a normal range even though there is a fairly marked deficit in the plasma volume and in the extracellular fluid compartment (roughly equal to the sodium thiocyanate space).

Gendel and Fine[60] have shown that distention resulting from intestinal obstruction or strangulation causes a rapid diminution in the plasma volume. While distention undoubtedly greatly accelerates the loss of body water, serious consequences may result from dehydration when distention is slight or absent. Toxic products or peritonitis may cause death in closed loop obstructions[61] or when strangulation is present[62] but evidence has been obtained which seems to indicate that death due to a simple mechanical obstruction may in some instances result solely from alterations in body water and salts.[14]

The fact that patients with severe diarrhea often develop a clinical picture resembling that seen in some cases of simple intestinal obstruction lends support to this concept. In regard to the importance of the fluid and electrolyte loss in diarrhea it has been stated by Marriott, Hartmann, and Senn[63] that "it has also become apparent that the severe toxic symptoms, the so-called 'alimentary intoxication' are the secondary results of disturbances in the chemical equilibrium of the body brought about as the result of loss of water, salts and organic material by way of the gastrointestinal tract, and that the development

TABLE VI. BLOOD STUDIES ON DOGS WITH SIMPLE MECHANICAL INTESTINAL OBSTRUCTION

DOG NO.	LEVEL OF OBSTRUCTION	DURATION OF OBSTRUCTION	PER CENT CELL VOLUME HEMATOCRIT	PLASMA CHLORIDE (MEQ. PER 1.)	PLASMA PROTEIN (GM. PER 100 C.C.)	PLASMA VOLUME (C.C.)	PER CENT CHANGE IN PLASMA VOLUME
C-5	Pylorus	0	47.5	111.2	6.63	935	
		2	51.8	97.2	7.97	745	–25
C-6	Pylorus	0	42.4		6.86	1,148	
		1	45.3		8.02	866	–25
		3	45.3	73.6	9.23	760	–34
360	Pylorus	0	49.4	112.0	6.80	637	
		1	65.0	102.3	9.36	498	–22
316	Jejunum	0	43.5	110.0	5.94	565	
		2	57.0	80.1	8.40	431	–24
42-9	Jejunum	0	46.0	108.4	5.95	835	
		3	63.0	107.1	8.71	578	–31
319	Ileum	0	37.6	110.8	5.62	655	
		4	35.2	106.6	5.69	495	–25
338	Ileum	0	46.2	112.6	5.83	850	
		2	47.6	107.6	6.09	670	–21
		4	46.1	111.7	6.02	648	–24
345	Colon	0	51.6	103.6	6.76	812	
		8	54.2	87.5	6.53	640	–21
		13	52.5	80.9	8.04	445	–45
42-7	Colon	0	47.6	105.2	6.58	600	
		10	53.8	86.8	6.03	558	– 7
		14	55.2	77.5	5.37	392	–35

of the clinical picture of intoxication depends more upon the degree and severity of the diarrhea than upon the nature of the underlying cause."

In patients with intestinal obstruction, a reduction in body fluids and in the plasma volume may occur in one or more of the following ways: (1) reduced intake, (2) excessive loss (vomiting, perspiration), (3) distention, (4) strangulation (with hemorrhage or transudation of fluid), or (5) infection (exudation of fluid).

On admission to the hospital, patients who have had obstruction for a few days or longer often have an elevated blood urea. This is well recognized and is a result of inadequate fluid being available for the excretion of the nitrogenous waste products (prerenal azotemia). Not infrequently such patients will show a trace of albumin and a few blood cells in the urine pre- and postoperatively, and even though the kidneys excrete 600 to 1,500 c.c. of urine a day, the blood urea remains elevated or, after a return toward normal, will subsequently rise. The elevated blood urea concentration occurs in such illnesses and in other seriously ill patients because of the existing kidney damage (the urinary specific gravity is usually low [1.002 to 1.012] demonstrating that the power of adequately concentrating urine has been lost), and because of an accelerated catabolism of the body proteins. Haden and Orr[58] pointed out that some patients may excrete from 10 to 33 Gm. of nitrogen per twenty-four hours following operation. Therefore, as these workers[58] and others[64, 65] have shown, there is usually an increased amount of nitrogen to be eliminated. In dehydrated patients the importance of an excessive catabolism of body proteins, poor kidney function, and the lack of an adequate quantity of water to eliminate the nitrogenous waste products has been well stressed.[17]

TABLE VII. PRERENAL AZOTEMIA IN A CASE OF INTESTINAL OBSTRUCTION (ILEUM)
(B. E., 45 YEARS OF AGE)

DATE	HEMOGLOBIN (GM. PER 100 C.C.)	PLASMA CHLORIDE (MG. PER 100 C.C.)	BLOOD UREA (MG. PER 100 C.C.)
3/27	15		
3/28	15	460	154
3/29	15		140
3/31	15	471	54
4/3		448	
4/4			251
4/6	12.5	461	116
4/9		454	64
4/11	12.0	482	28

In Tables VII and VIII are shown the alterations in the blood chemistry which occurred in two cases with a simple obstruction of the terminal ileum due to adhesions. The first patient, a 45-year-old man (Table VII), was admitted to the hospital with a five-day history of intestinal obstruction. He was treated conservatively for twenty-four hours by intestinal intubation, but because he did not respond well, operation was decided upon (March 28, 1945). The patient improved for the first three days postoperatively and the blood urea was decreasing toward normal. The urinary output ranged between 800 to 1,500 c.c. and contained small amounts of albumin and cells. He developed pneumonia on the fourth postoperative day and penicillin (20,000 units every two hours) was begun. The pulmonary complications improved, but on the seventh postoperative day the blood urea concentration had risen to 251 mg. per 100 c.c. At this time the patient was mentally confused and showed a uremic frost. He was given 4,000 to 5,000 c.c. of 5 per cent dextrose in distilled water daily with a resulting increase in the urine volume and within one week's time there was a return of the blood urea concentration to normal. Similar findings occurred in the second patient, who was a 48-year-old woman with a four-day history of obstruction. She was operated upon March 4, 1945, and six days later the blood urea was near normal. During this period she had received adequate intravenous therapy and had excreted an adequate amount of urine. Subsequently she was given a diet by mouth, but because it was taken poorly the food and fluid intake decreased. The urinary output

TABLE VIII. PRERENAL AZOTEMIA IN A CASE OF INTESTINAL OBSTRUCTION (ILEUM)
(E. R., 48 YEARS OF AGE)

DATE	HEMOGLOBIN (GM. PER 100 C.C.)	PLASMA CHLORIDE (MG. PER 100 C.C.)	BLOOD UREA (MG. PER 100 C.C.)
3/4	13.5		
3/10	11.5		45
3/12	9.0		
3/16			128
3/19	9.5	421	156
3/23			148
3/31	9.0	531	46
4/4	9.25		35

which had been higher, then decreased to between 800 and 1,300 c.c. per day, but in spite of what appeared to be a fairly adequate output, the blood urea rose. The specific gravity of the urine ranged between 1.004 and 1.013 and because of her clinical condition it was felt that in all probability she was in a period of excessive nitrogen destruction (because of an inadequate caloric intake, pulmonary complications, dehydration, and the dehiscence of the abdominal wound). When adequate fluid was provided and the urine volume increased to around 2,000 c.c. per day, the blood urea returned to normal.

Similar findings were observed in another case. The chemical alterations noted are shown in Table IX. This 66-year-old man was admitted to the hospital with pyloric obstruction. There had been vomiting for several days and he had taken very little fluid. The blood urea was only slightly elevated on admission and although gastric suction was begun he was permitted small amounts of fluid by mouth and given an additional 2,500 c.c. of fluid daily by vein. Because of the prolonged obstruction with dehydration and a posterior duodenal ulcer which had perforated through into the common bile duct, the patient was apparently in a marked nitrogen catabolic phase. On May 5, at surgical consultation, it was felt that the uremia was due to an accelerated catabolism, inadequate caloric intake, and dehydration. The fluid and caloric intake was increased and the patient showed a rapid improvement. Eventually the inflammatory reaction subsided and the patient was then able to get along well on an oral intake alone.

TABLE IX. PRERENAL AZOTEMIA IN A PATIENT WITH PYLORIC OBSTRUCTION
(C. A., 66 YEARS OF AGE)

DATE	HEMOGLOBIN (GM. PER 100 C.C.)	BLOOD UREA (MG. PER 100 C.C.)	TOTAL DAILY FLUID (INTAKE IN C.C.)	DAILY OUTPUT OF URINE (C.C.)
4/30		45		
5/3	12.0	240	2,470	480
5/4		260	2,750	260
5/5	13.5	300	4,260	520
5/7		268	4,440	1,550
5/8		242	4,710	1,010
5/9	11.0	203	5,600	2,300
5/12		111	4,900	2,310
5/15	9.0	36	3,700	3,650
5/17		28	3,500	2,420

While the cause of uremia seems quite obvious, it was surprising to find that some of the physicians who observed these cases felt that the urine output was adequate and that the kidneys had failed.

Since such patients often cannot excrete excesses of salt well, and the protein reserves are depleted, it is essential that they be given 4,000 to 5,000 c.c. of 5 to 10 per cent glucose in distilled water if the urine volume is to be raised sufficiently to clear the nitrogenous breakdown products. A similar phenomenon may occur during convalescence from a burn.[15] Here again there is a period of accelerated catabolism when the kidneys are not able to work at the highest degree of efficiency.

In a series of burned patients recently observed,[15] the hematocrit changes were not believed to be indicative of the decrease in the plasma volume. Moyer, Coller, Vaughan, Iob, and Marty,[66] in studying experimental burns, recently pointed out that changes in the hematocrit in this type of injury are dependent on the rate of loss of the plasma portion of the blood and the loss of red cells (destruction and stasis of cells in the injured area). Thus, if only plasma is lost a high cell volume will result, but if both cells and fluid are being lost, as frequently occurs, the hematocrit may be normal or may even be decreased if the cells are being removed from the circulation as fast or faster than is the liquid portion of blood. In other instances it has also been noted[15, 67] that the giving of large amounts of plasma to severely burned patients will not maintain a normal plasma protein concentration. In many moderate to severely burned patients the plasma protein concentration will apparently decrease from the third to the tenth day regardless of the type of shock therapy (plasma or normal saline solution) or diet employed. These changes result because of some loss of protein, but also in many instances the decrease in the protein concentration is partially due to an existing hemodilution, and as the edema subsides the protein concentration rises toward normal.

SUMMARY

The point that is so frequently lost sight of in interpreting chemical data is that the size of the blood volume and the extracellular and intracellular fluid compartments are often markedly altered in diseased states, as well as the solute concentrations. Thus, when only the solute concentration is known it offers little assistance in prescribing treatment unless one has a thorough understanding of the volume changes which might be present.

The handling of the seriously ill patient from a metabolic standpoint, therefore, can be done efficiently only if a thorough knowledge of the chemical and physiologic alterations which may occur is available.

It should not be necessary to do complete nitrogen balance studies, plasma volumes, etc., on each patient, but rather it is important that the changes which do occur are recognized clinically and thus a logical therapy prescribed. Much can be derived from a careful history, physical examination, and close observations of the patient and his response to therapy. Fortunately, most cases present very few problems, and it is primarily the individual who is seriously ill that needs such special care. In patients who have been sick for more than several days there are often significant alterations in the metabolic state due to a deficient caloric and fluid intake. The use of parenteral therapy (amino acids, glucose, vitamins, water, and salts) has recently been well discussed by Butler and Talbot[68] and should be used if adequate diets cannot be taken orally. Along with the blood chemistry an accurate intake and output record is extremely valuable (type and amount of fluid should be recorded).

Determination of the specific gravity and the amount of chloride and nitrogen in the twenty-four hour urine sample may be of value in many of the more seriously ill patients, but again should never be relied on entirely to interpret the patient's state and his needs.

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ARTERIAL INJURIES OF WARFARE

Complications and Management

Captain Alexander P. Preston, Medical Corps, U.S.N.R.

A CONSIDERABLE number of interesting lesions of the larger arteries and veins have been seen among the casualties of World War II because of frequent injury by fragments of small size. Multiple high-speed fragments produce small perforating wounds, which have many times not been fatal and which have been associated with partial or incomplete laceration of blood vessels, giving rise to recurrent hemorrhage, false aneurysm, and arteriovenous fistula and aneurysm. A fragment, ½ cm. in size, can produce a small perforation in the wall of an artery or pass between an adjacent artery and vein, producing injury to the wall of each without destroying the continuity of the vessels and without producing massive hemorrhage. An increasing experience with this type of vascular injury and with its complications has developed certain principles and made clear the advantages of certain methods of management, which have greatly advanced our understanding of the problems associated with these injuries.

The patients in the series of twenty-six lesions in twenty-five cases described here were seen during the South and Central Pacific campaigns, at periods following injury, varying from a few hours to the time of arrival at a base hospital after several days or weeks. They present a wide variety as to the nature of the injury, the course of the lesion, and the type of complication as well as the management and operative treatment.

The common characteristic factor in this type of injury is *incomplete* arterial laceration, for it is partial section of the arterial wall which gives continued and recurrent bleeding with its resultant complications. Complete section of a larger artery, when not ligated, if not immediately fatal, is followed by retraction of the stump and natural occlusion of the lumen by clot, in the presence of a much lowered arterial tension, very possibly aided by the intimal plug produced by the retraction of the elastic wall. If the hemorrhage stops under such circumstances, further complications are rarely seen. The opportunity to observe such a situation was presented in a noncombat injury, in which fracture of the lower third of the femur was followed by immediate ischemia and absence of pulsations in the lower leg and foot but with no hematoma or swelling of the thigh. He was admitted to the base hospital two days after injury with an early demarcating gangrene just below the knee and a small puncture wound compounded from within on the lateral surface of the lower thigh, which had been primarily cleaned and dressed, and appeared clean. It was felt that there was a complete section of the lower portion of the femoral artery. While awaiting the final demarcation of a dry gangrene at the knee, prophylactic tetanus and gas antitoxin had been given, and without warning, sudden appearance of a virulent gas bacillus infection through the leg and thigh made necessary

Received for publication, Jan. 25, 1946.

emergency operation, which was a guillotine amputation through the fracture site and drainage of the muscle groups of the thigh. It was possible at that time to observe directly nature's response to the arterial injury. There had been complete section of both artery and vein by the sharp edge of the femoral fragment and these two vessels lying together in the end of the stump were found to be filled with a firm clot for a distance of 6 to 8 cm. from the cut end. The artery was found to be somewhat dilated and a faint pulsation was transmitted through the clot to the cut end of the artery, from which, however, there was no evidence of hemorrhage. There was a moderate amount of fibrinous exudate around these vessels, but there was no evidence of any hematoma in the tissues around the fracture site.

However, with partial section of the wall of the artery, or a small perforation, the retractile force of the elastic wall serves only further to enlarge the size of the opening and reduce the possibility of spontaneous cessation of the hemorrhage. This is indicated in Fig. 1, which shows diagrammatically the incomplete arterial laceration and the mechanism of development of the several complications which commonly follow. In Table I and Fig. 2 are indicated the anatomic location and the distribution on the arterial tree of the lesions in this series.

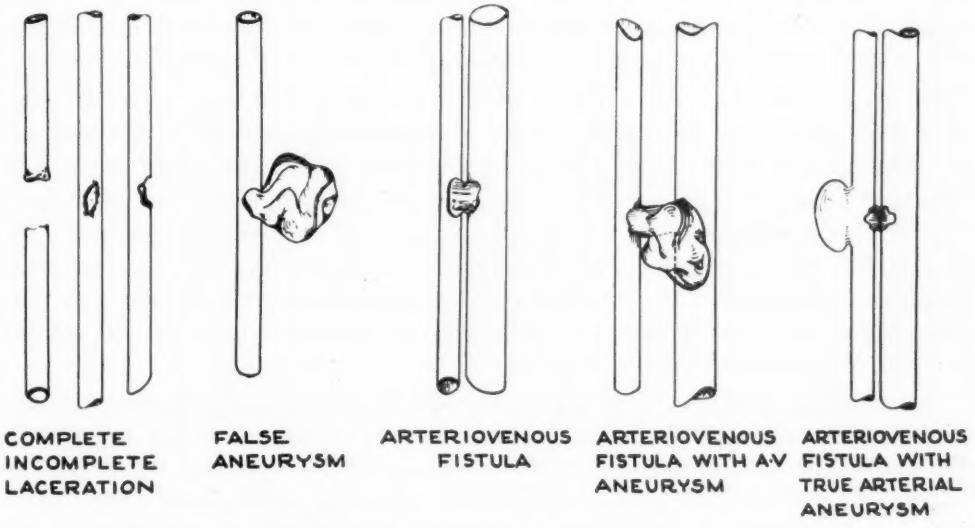


Fig. 1.—Types of lesions complicating incomplete arterial laceration.

With partial arterial laceration, under varying circumstances, the pathologic process may follow any one of a number of courses that lead to the complications demonstrated in this group of cases. Obviously, there may be spontaneous arrest of the hemorrhage or continued bleeding to the exterior through the wound. Of extreme importance, and not always recognized, is the group in which there is the formation of a hematoma in a partially opened wound with repeated recurrence of delayed hemorrhage from the deep artery, with a small perforation or partial laceration which has not been effectively dealt with. When the arterial injury is deep under fascial planes or muscles where there is no ready

TABLE I. INCOMPLETE ARTERIAL LACERATION; LOCATION OF LESIONS

ARTERY	ARTERIOVENOUS FISTULA	PULSATING HEMATOMA FALSE ANEURYSM	RECURRENT HEMORRHAGE	LACERATION AND LIGATION
Ulnar		xx		
Radial		x		
Brachial	x	xxx		
Axillary		xx		
Subclavian		xx		
Lateral thoracic			x	
Carotid	xx			
Supraorbital	x			
Femoral	xx			x
Popliteal	x	x		
Posterior tibial		x	xxx	
Anterior tibial		x	x	
Total	7	13	5	1

exit to the exterior, a hematoma frequently develops, its size being dependent upon the resistance offered to the escaping blood by the surrounding tissues and upon how quickly tissues build up a pressure equal to the intra-arterial tension to stop the bleeding. A small hematoma such as this may be absorbed. A larger one, where there is a center of fluid blood pulsing constantly from the artery, will lead to the formation of a definite fibrous wall to produce the so-called false aneurysmal sac through peripheral clot organization and fibroblastic proliferation. From this stage there may be partial regression and gradual diminution in the size of the sac, or repeated hemorrhage with enlargement, either gradual or sudden, to a point where through pressure on the artery itself or on the collateral channels by the swelling, ischemia-serious impairment of the circulation of the extremity may be found. The presence of a concomitant laceration of an adjacent vein may lead to the development of a permanent arteriovenous communicating channel, with or without an associated aneurysmal sac, which in turn has a pronounced tendency toward contraction and may lead to partial or rarely complete healing of the lesion.

Among the factors which may affect the course of the clinical pathologic picture are the size of the injured artery, the size of the laceration in its wall, the size of the path of the missile which may serve as an exit for the blood, the nature of the surrounding tissues such as the tightness of the fascia or the proximity of loose areolar planes where the blood may dissect, the tightness of the compression applied with the first emergency dressing, roughness or gentleness in transportation, adequacy of splinting, and the presence of a concomitant laceration in an adjacent vein, whether the early level of arterial tension is low from shock or high from active intravenous therapy.

In the necessary haste of evacuating large numbers of casualties these lesions are frequently overlooked and it is important to stress the fact that the presence of small aneurysms is not always apparent upon a cursory examination. A through-and-through bullet wound usually heals promptly without infection and the deep aneurysm may present no external signs. In a number of the cases the aneurysms were discovered late, by careful examination, by the patient him-

self, or by the sudden appearance of deep or superficial hemorrhage. A stethoscope is often the only way to identify the presence of an aneurysm. With regard to the local signs and symptoms, several features may be noted. Of course the bruit and palpable thrill, which are systolic in time in false aneurysm and continuous throughout both systole and diastole without interruption in arteriovenous fistulas, present the diagnostic evidence for the presence of these lesions, and the presence of a palpable or visible pulsation, though commonly found, is *not* a constant or necessary diagnostic sign.

In two of the unrecognized cases, severe throbbing pain called attention to the local lesion.

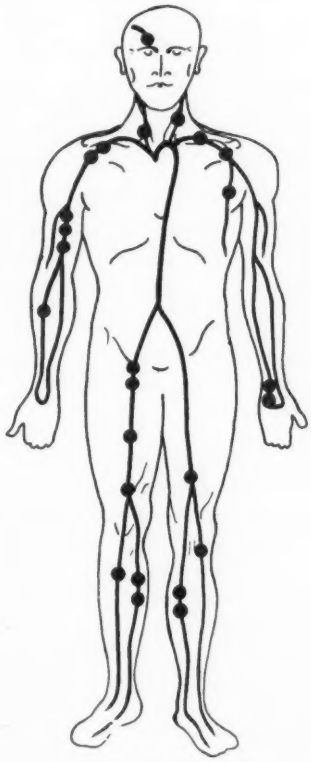


Fig. 2.—Arterial injuries distribution.

CASE 1.—C. C. received a bullet wound of the lower part of the right upper arm in the supracondylar area which produced a compound, comminuted fracture of the lower end of the humerus; primary débridement was done and a cast applied four days later. Severe, steady throbbing pain developed in the lower arm, which was not relieved by cutting of the cast. The hand became numb and the pain continued with extreme severity in the lower arm and above the elbow. Following his evacuation from the beach, he was seen at the base hospital seventeen days after the injury. When the cast was removed, a 6 cm. pulsating mass was present in a large, granulating wound in the lower mesial surface of the upper arm. Operation was done at once and a false aneurysmal sac was identified, which, after the brachial artery was divided and ligated, just above and below, was opened and evacuated. There was immediate relief of pain. No impairment of the circulation of the forearm and hand was noted. The humeral fragments were brought into line and a second cast was applied.

CASE 2.—F. S. received a through-and-through bullet wound in the lower left thigh, which healed cleanly and without incident. He was evacuated with slight swelling above the knee and with minimal stiffness and admitted to the base hospital one month after injury. At that time, notes were made of the healed wounds and slight swelling about the knee, with limitation of motion but no effusion. He was sent to a convalescent ward and put on exercises and physical therapy. Three weeks later, there appeared sudden, severe pain and swelling above the left knee. Examination revealed grade III, tender, tense swelling both anteriorly and posteriorly, with a barely definable, deep pulsation in a small 2 cm. area in the popliteal area, and a systolic bruit heard only in this area. There was no pulsation in the arteries of the foot, and increasing pain and swelling developed. Operation was performed because of threatened ischemia. A false aneurysmal sac of the popliteal artery, from which there had been a leak into the tissues, was found, evacuated, and the artery ligated and divided. This case was recognized because of sudden pain from the secondary hemorrhage. Operation was done at seven weeks, and popliteal ligation did not affect adversely the circulation of the distal lower leg. The course was smooth and the patient became ambulatory.

Another sign which is prominent is the sterile inflammatory reaction surrounding the hematoma. This is generally of marked degree and frequently produces induration and a hard, red, brawny swelling which may be quite extensive. It should be stressed that it is common to have no fluctuation, and frequently no pulsation, or one which because of the induration is not readily evident. These factors are likely to lead to uncertainty or a mistake in diagnosis. When, because of the inflammatory redness and induration, the surgeon is led to consider the lesion to be an abscess, his error may be embarrassing and costly. The valuable sign, of course, is the audible bruit, which should always be searched for. This is illustrated by Case 3.

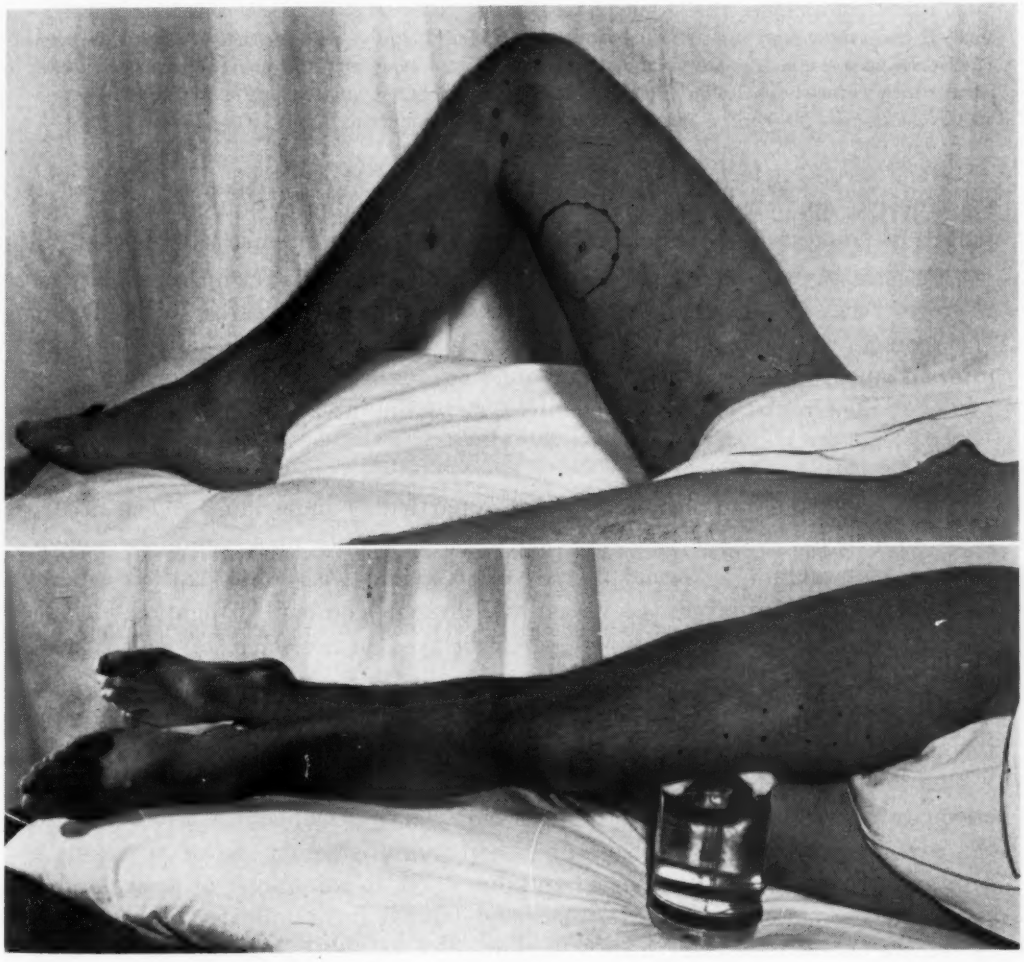
CASE 3.—J. P. received a bullet wound of the right upper arm which healed under routine treatment and caused no trouble except for moderate throbbing pain, until he was admitted to the hospital eighteen days after injury. He had an injury to the hand, for which he was being treated on the orthopedic service, when suddenly, six weeks after injury, he developed an increase in the pain of the upper arm with a tense, tender, red, indurated, grade III swelling, extending both anteriorly and posteriorly almost the length of the humerus. This was so characteristic of an inflammatory reaction that incision and drainage was at first considered, when further examination showed a minimal pulsation and the pathognomonic systolic bruit audible over the mesial surface of the arm. Abscess could have been considered readily if an aneurysm had not been suspected and verified. Because of the imminence of circulatory insufficiency in the extremity, an immediate operation was done and after the axillary artery was isolated in the axilla and a tape placed about it to control the blood supply, dissection at the site of the lesion through densely infiltrated tissue with much local edema demonstrated the false arterial sac, which was opened, evacuated, and the artery divided and ligated. This was just below the profunda branch and there were no symptoms of circulatory insufficiency.

A prominent characteristic of both the false aneurysm and the arteriovenous fistula is the common tendency for spontaneous regression and contraction of the lesion under observation, which is striking in several of these cases. Therefore, postponement of the operative attack on these lesions during an adequate period of observation is indicated—because of this tendency, because of the greater ease of the surgical approach through tissues in which the induration and the acute inflammatory reaction have subsided, because of the decrease and disappearance of the infectious factor with the passage of time, and, finally, because of the obvious advantage of allowing for the maximum development of an

adequate collateral circulation. During this period, exercises may be carried out to this end by systematic closure of the lesion by pressure for increasing periods of time, which provides the best stimulus to the development of collateral channels.

CASE 4.—F. K. was hit in the right thigh by a small mortar shell fragment which produced small wounds that healed promptly after emergency treatment. Subsequently he noticed only soreness and aching in the thigh. The lesion was not recognized until admission to the base hospital fourteen days following the injury, when the patient himself noticed the

A.



B.

Fig. 3.—Arteriovenous aneurysm, femoral artery. A, Circle indicates pulsating mass below healed wound of entry. Outer dotted line indicates area of transmitted continuous bruit and thrill. B, Mechanism of closure exercise.

presence of a buzzing mass in the thigh with increasing discomfort and swelling of the leg and foot. Careful examination at this time revealed, on the anteromesial aspect of the right mid-thigh, a 7 cm. diameter egg-shaped pulsating mass visible and palpable, with a continuous palpable thrill and a continuous audible bruit over a large surrounding area, which were eliminated by compression of the femoral artery. This mass was held for two

months before operation while the arteriovenous fistula was closely observed. Closure exercises were carried out by the patient through this period in the manner shown in Fig. 3 and the size of the lesion showed a marked decrease prior to the time of operation. Compression of the lesion was begun at fifteen minutes, three times a day, and gradually increased to one hour, four times a day. This was checked with a stethoscope and was effective in completely shutting off the flow of blood through the femoral artery. The weight of the man's leg was adequate to accomplish this. At first the closure produced marked cyanosis in the leg and foot and some discomfort, but this improved gradually day by day so that just prior to operation interruption of blood flow through the lesion produced practically no objective change in the color of the extremity and was accomplished with no discomfort to the patient. He was operated upon eleven weeks after injury under a tourniquet placed about the upper thigh. The sac was identified lying just mesial to the femoral vessels, and division and ligation of the artery and the vein both proximally and distally were carried out with excision of the vascular segments, the fistulous tract, the aneurysmal sac, and a great many collateral veins which entered the lesion from below. This man had a smooth postoperative course and was evacuated to the United States, ambulatory and asymptomatic.

In a second arteriovenous fistula, to be described, between the carotid and the internal jugular, similar exercises produced a diminution in size of the pulsating mass and shortening of the bruit during the preoperative period.

In most cases an optimum elective time may be selected for operative repair. However, occasionally emergency intervention may be indicated by recurrent hemorrhage, by sudden increase in the swelling and pain from active bleeding into an aneurysmal sac or the surrounding tissues (which may imperil, by pressure, the circulation in an extremity), or by the threat of, or actual, rupture.

RECURRENT HEMORRHAGE

Recurrent delayed hemorrhage is of particular importance. The occurrence of delayed secondary hemorrhage from the depth of a wound is enough evidence to warrant a formal operative procedure with wide exposure, demonstration of the injury to the vessel, and division and careful ligation. These cases in which there has been recurrent delayed hemorrhage, of which there are five, presented a total of sixteen episodes in which, prior to their final adequate treatment, hemorrhage from an incompletely severed artery had been ineffectively treated by dressings, pressure, packing, clamping in the depth of a wound and deeply placed sutures in the general location of the bleeding without adequate visualization and definition of the artery. Temporizing procedures in the presence of such hemorrhage are wholly unsatisfactory, never represent a solution to the surgical problem, and have led to situations of considerable danger to the patient. The artery must be divided and the ligated ends allowed to retract before the hemorrhage will stop. Several cases illustrate particularly this type of problem, such as Case 5.

CASE 5.—T. H. received a deep flesh wound in the left calf; he was brought on board ship after severe hemorrhage, and given the usual treatment. Nine days later he had sudden severe hemorrhage from the leg wound, controlled with a tourniquet, but no bleeding point was found and the wound was packed, which stopped the hemorrhage for the time being. The red count was down to 2.3 million and he was given plasma and transfusions. Four days later there was a second severe hemorrhage, when he was taken to the operating room and the bleeding point found, but when the vessel could not be isolated, a deeply placed

suture was found apparently to control the bleeding. He was given another transfusion of 1,000 c.c. At another hospital on four other occasions there were minor hemorrhages from the wound, which were controlled by packing. He came under observation at the base hospital seventeen days after injury, when a large, ragged soft tissue wound involving two-thirds of the calf was found. There was a minimal, slow oozing from the wound. Four days after admission and twenty-one days after injury, a sudden massive hemorrhage developed and when, this time, he was taken to the operating room, the leg was widely opened and the posterior tibial artery isolated, divided, and ligated. Following this, the course was smooth.

CASE 6.—S. K. had a deep flesh wound in the right calf and before admission to the base hospital had four episodes of hemorhage from the leg treated by dressings and packing. He was admitted twenty days after injury, and on the day after admission, during dressing, there was a sudden hemorrhage from the wound. He was taken to the operating room and the artery and vein were ligated in continuity. Six days later a sudden further hemorrhage occurred and at reoperation this time the posterior tibial artery was located, divided, and ligated. Following this, the course was smooth.

CASE 7.—S. V. was admitted fourteen days after injury, with small healing wounds in the lower posterior left axilla and in the pectoral fold anteriorly. He had partial loss of median and ulnar nerve function, and presented considerable induration of the axilla both anteriorly and posteriorly. On admission, a spurting hemorrhage was noticed from the posterior wound, which was a very small puncture wound. Pressure controlled this, but on three subsequent occasions this recurred in small degree and was handled promptly by pressure. The operation was postponed in the case because of the complication of threatening infection in this area and the extent of the procedure which would have been necessary to expose the entire axilla in searching for the unknown source of the bleeding. It did not seem as though the axillary artery were involved. Finally, however, seventeen days after admission, the swelling became much more extensive, with induration and pain in the entire axilla and edema of the arm, and at operation, in which wide exposure of the axilla was done, exploration revealed a large hematoma in the lower axilla into which there was active bleeding from the lateral thoracic artery, which had a tangential laceration. This was divided and ligated with silk. There was no injury to the axillary artery but the picture at operation and the course substantiated the necessity for definitive surgical attack on all cases of recurring hemorrhage and the uselessness of temporizing procedures.

Further indication for emergency operation is sudden hemorrhage deep in an extremity into a false aneurysm which produces swelling and shuts off circulation to the distal part of the extremity and makes urgent immediate operation—a situation which obtained in four of our cases.

Of course, rupture of an aneurysm presents a dramatic indication for operation. In two cases there was rupture, one of an arteriovenous aneurysm to the exterior and one of a subclavian false aneurysm subcutaneously. Fortunately, in each case it was possible to apply emergency pressure until the patient could be taken to the operating room.

CASE 8.—A. S. received a bullet wound in the right groin, just below Poupart's ligament, which made its exit in the lower part of the right buttock posteriorly. Both of these wounds healed promptly but he continued to have pain and when he was seen about four weeks after injury he presented a pulsating mass 4 cm. in diameter in the right groin with a palpable thrill and audible bruit. This was just below the site of the wound of entrance and the mass was very superficial and thin walled. He also had an incomplete lesion of the sciatic nerve with partial posterior tibial and peroneal defect. At six weeks, while still in bed, this mass ruptured to the exterior with massive hemorrhage which was controlled by a corpsman who at once applied pressure until the patient could be taken to the operating room. At operation a tape was placed about the external iliac artery which, due to the marked collateral circula-

tion, was not effective in producing a bloodless field because of supply through the branches of the internal iliac. (To control the vessels satisfactorily in this situation it is necessary to place a tape around the common iliac artery.) With some difficulty a four-way excision of the arteriovenous lesion was performed. This involved ligation of the common femoral well above the point of the exit of the profunda but no circulatory embarrassment of the leg followed and the result was good.

CASE 9.—J. H. was hit by a flying fragment in the posterior part of the shoulder on the left. The fragment came to rest in the left upper anterior part of the chest. He was seen at another hospital six days after injury, at which time a large pulsating mass was found in the left infraclavicular area with a loud systolic bruit. In time the shoulder wound was healed and there was marked pain in the entire shoulder. During this period of observation some enlargement of the aneurysm occurred, but the patient was evacuated by ship six weeks later. Aboard ship, increase of the size of the mass was noted and rupture of the aneurysm occurred shorly after, with massive swelling of the tissues over the entire left side of the chest. Immediate pressure was made over this area as well as the chest and the man was taken to the operating room where the medial part of the left clavicle was subperiosteally resected. Proximal to the mass the left subclavian artery was isolated, divided, and ligated. The same procedure was carried out on the subclavian vein. Due to the technical difficulties and the patient's condition at this time it was not possible to deal with the aneurysmal mass itself. When it seemed as though the ligation would control the hemorrhage, the operation was concluded and the wound closed. The patient received 1,250 c.c. of blood on the operating table and after operation no further hemorrhage occurred. The circulation of the left arm remained good although the radial pulse disappeared. This man had a smooth convalescent course.

Harbison, in his recent report of aneurysms from Europe, particularly pointed out that this occasional tendency toward sudden hemorrhage or rupture was enough indication to demand operation before the evacuation of these patients to the rear with false aneurysms. This observation, I believe, is quite well taken, for the exceptions to the general rule that aneurysms of this sort tend to contract are frequent enough to make transportation of the unoperated cases definitely hazardous.

One of the observations made, which we were surprised and gratified to find true, is that the effectiveness of the collateral circulation in this group of young patients well exceeded what one would be led to count on from a consideration of the anatomic channels available and the elapsed time. In the cases in which our hand was forced by the occurrence of some complication, and interruption of the brachial or popliteal artery was done, there was no question about the circulatory efficiency of the extremity. In one brachial artery ligation, the radial pulse was palpable, though weak, immediately after operation, and in another it was palpable on the first postoperative day. In one subclavian ligation, the radial pulse appeared on the third day.

NERVE LESIONS

It is well recognized that, due to their anatomic location, injuries to peripheral nerves are very likely to be associated with arterial wounds. In eleven cases in this series there were definite nerve lesions which were distributed among most of the major nerves in the body. In only one case was it feasible to carry out any procedures directed toward the restoration of the nerve function at the time of the operation upon the arterial lesion. Our experience has been that

improvement during the preoperative period of observation has been almost negligible and that restoration of function following operation which removed the cause of local infiltration of the tissues including the nerve trunks has been very disappointing. Follow-up reports by letter were obtained from many of this group of patients and the ultimate results are in accord with this opinion. Late operation in the United States was done in one case of subclavian aneurysm with exploration of the brachial plexus and lysis of the nerve trunks but without significant improvement.

Elkin and Woodhall reported, from an Army general hospital, twelve cases of associated neural and arterial damage and emphasized a conservative attitude with regard to the technical procedure on such injured nerves. They bring up the point from their experience that nerve damage may decrease during the preoperative time of observance before arterial operation is done.

OPERATIVE TREATMENT

The operative problems of arterial injury are obviously divided into those associated with the primary emergency treatment of the injury in the field and those associated with the management of the complications of these injuries as they are seen in hospitals to which the casualties have been evacuated. The problem at the front of immediate repair of arterial injury by suture, with grafts, and the use of the Blakemore tube has not been presented in this group.

Most of the patients in the series herein reported were seen from ten days to several weeks after injury and the problems therefore concern themselves with the management of the late complications of incomplete arterial lacerations. In this series, operation was done on twelve false aneurysms, five arteriovenous fistulas, and in four cases of hemorrhage.

With regard to the operative procedure, several factors have been found to be of major importance. The first is the necessity for perfect control of bleeding which should always be secured in advance except where it is anatomically impossible. Although the opinion is generally held that a tourniquet should not be used, it is helpful to have a blood pressure cuff strapped in place on the extremity, where it may be inflated promptly if necessary. Several of the patients were operated upon with the blood drained from the extremity and the tourniquet inflated and this procedure was found to be of great help. Where the tourniquet is not used or where the location makes it impossible, the placing of a tape or rubber tubing about the surgically exposed main artery proximal to the lesion is essential. The artery can usually be isolated and controlled at a distance from the lesion. This should be the first step of every operation and the mass should never be approached or opened without this precaution. With an incomplete laceration of an artery with or without a false sac or with a fistula, the vessel should never be ligated in continuity. This type of ligation of any larger artery is dangerous because of the fact that there is no stump to retract and because of the likelihood of late erosion and hemorrhage or restoration of the continuity of the lumen of the vessel, both of which complications are not uncommon. Furthermore, ligation in continuity should be avoided because of its

effect in increasing the peripheral vasospasm including many collateral channels farther down in the extremity. No clamp should be tied which has been blindly placed and, although effective in stopping the bleeding, has not been placed on the artery under direct vision. The artery should be divided, in partial laceration, at the site of the injury, or, in aneurysm, at sites selected proximal and distal to the lesion, and both ends doubly ligated with silk. The accompanying veins should be ligated in all cases in which the circulatory efficiency of the extremity is in the least doubt. A good rule is to do this unless after division of the artery a positive Henle-Coenen test shows a pulsation in the distal stump indicating good circulation.

The sac in false aneurysms may or may not be resected, depending upon local conditions. The primary consideration here is the added operative trauma necessarily resulting from resection of the sac and the consequent increase in postoperative edema and swelling which has a directly deleterious effect upon the channels of collateral circulation by pressure. In cases of borderline circulatory efficiency this should be carefully avoided and all dissection and handling of tissue reduced to a minimum. Furthermore, the sac is very likely to be in intimate relationship to nerve trunks which may be injured further in the procedure. Our plan has been to deal with the artery both proximally and distally and then open the sac and evacuate the clot. In some small aneurysms the sac may be opened directly, the laceration in the arterial wall demonstrated, and division of the artery done at this point.

In the arteriovenous aneurysm, as is well known, a four-way ligation of the artery and vein with division of these vessels, removal of the sac, the fistula, and interruption of all the collateral channels is the only procedure which will give a cure. It is surprising to find the number of collateral channels in connection with an arteriovenous lesion which seem to spring up from every side. Because of these, simple ligation without excision will give an immediate recurrence of the lesion, and proximal ligation of the artery, of course, always leads to gangrene in the extremity. In some arteriovenous aneurysms in unusual locations where resection is impossible technically, procedure has been reported in which a four-way ligation was used coupled with direct transvenous obliteration of the fistula.

Of course, the interruption of sympathetic impulses to an extremity where the efficiency of collateral channels may be in doubt is of the greatest importance to the surgeon operating upon these lesions, particularly in cases in which operation must be undertaken as an emergency before time has elapsed for proper development of collateral channels. This may be accomplished either through direct thoracic or lumbar sympathectomy when practicable or by injection of the dorsal or lumbar sympathetics with novocain immediately at conclusion of the operation and frequently thereafter as indicated. In some cases preoperative tests may be made of the circulatory efficiency by digital interruption of the arterial flow in the main vessel to an extremity proximal to the lesion. Of course, the ligation of the common carotid should always be approached with great caution. Dandy stated that compression for ten minutes with observa-

tion for the appearance of symptoms will give a true indication as to whether or not ligation can be done, and when necessary he has used a strip of fascia lata twice around the artery with partial compression for from seven to fourteen days before ligation. In a series of 600 cases reported by Pilz there were symptoms in 32 per cent. Probably the best rule is that over the age of 40 years, and in all persons with arteriosclerosis, the procedure should be seriously regarded and stage closure done.

In this series of cases the time of operation was from three to eleven weeks following injury. Those that were operated upon after the shorter interval were those demanding emergency procedures. It is possible that in some cases periods longer than two months might be needed in preparation for operation.

It was our good fortune to have only two amputations in this series. The first of these is reported in Case 10.

CASE 10.—R. L. received a stab wound of the right upper thigh for profuse hemorrhage. Immediate exploration was done and the common femoral artery and the deep femoral vein were ligated. He was admitted to the hospital seven days after operation with a line of demarcating gangrene at the mid-calf. The leg was refrigerated and after several transfusions was amputated in the mid-lower region.

The second amputation is described in Case 11.

CASE 11.—D. G. received a through-and-through machine gun bullet wound in the back of the right knee and was admitted three days later with a very tightly swollen leg with grade IV swelling and induration from above the patella to the lower calf, extreme pain, no palpable pulsations below the femoral artery, and early gangrene of the foot with cold blue skin in the distal half and in the heel. He had a hemarthrosis of the knee. Immediately upon admission he was taken to the operating room and a long releasing incision made in the fascia of the calf posteriorly to relieve the pressure to the full extent of the leg. This was packed open and the sympathetics blocked. Pulsation appeared in the popliteal artery following this procedure but there was no change in the level of discoloration in the foot. Ten days later examination disclosed in the wound in the lower popliteal space a pulsating mass with a thrill and a continuous bruit and it was apparent that an arteriovenous aneurysm had appeared in this location. The skin edges by this time were widely separated and the wound was granulating and not obviously infected. A closure of this lesion by pressure produced a rise in the blood pressure and a slowing of the pulse. It was thought that any procedure that might bring an interruption of the leak into the venous system and which would increase the pressure in the collateral branches past the knee would be of benefit. Accordingly, he was reoperated upon and a four-way excision of an arteriovenous fistula of the popliteal artery was performed. However, this produced no change in the circulatory status of the foot and a guillotine amputation was performed in the mid-lower region of the leg, following which there were no further complications.

The phenomenon of traumatic vasospasm is a very interesting one. Its nature is self-explanatory and it appears first as a compensatory mechanism to combat hemorrhage probably with its mode of action through sympathetic hypertonus. However, this effect may persist after the injury for as much as forty-eight to seventy-two hours and give quite undesirable effects in the prolonging of ischemia of the extremity. Actually this effect may spread from the affected extremity to other regions in the body, and it has been demonstrated to occur in sufficient degree to affect the circulatory balance even when the wound

is not in direct relationship to the artery. The treatment is threefold. Obviously the local débridement is indicated with the usual treatment of the wound; second, division of the injured artery, with interruption of the nerves in vessel walls; and third, interruption of the sympathetic impulses by paravertebral novocain injection.

In this series there were two cases of ligation of the common femoral artery, above the profunda. In the first, it had to be done immediately for a profuse hemorrhage and was followed by gangrene of the lower leg. In the second, the operation was delayed until spontaneous rupture of an arteriovenous fistula at six weeks and in this case no trouble was experienced with the circulation of the leg. Of course in early cases the relation of the site of ligation of the brachial or femoral artery to the point of branching of the profunda branch is of extreme importance. If operations can be delayed for a number of weeks it seems to make very little difference.

PHYSIOLOGY OF ARTERIOVENOUS FISTULA

A few words should be added with regard to some of the interesting features of arteriovenous fistulas with relation to the physiology of the circulation. When such a fistula from an artery into a vein is produced, if it is of any size, there is an immediate pulse rise and blood pressure drop, from the unaccustomed leak in the arterial tree. To compensate for this blood pressure drop, nature fairly promptly develops an increase in the total blood volume which in experimental animals has been demonstrated by Holman to be often up to 50 per cent. The size of the fistula and the proximity of the fistula to the heart determine the speed of appearance of these physiologic changes, and also their degree. There is progressive dilatation of the heart from the increased blood volume, without hypertension, which may bring on cardiac insufficiency of any degree. This complication is not constant and when it appears it is usually late, between two to six months after the production of the fistula. It is well known that cases have been recorded when extreme myocardial insufficiency of unexplained origin has been discovered to be dependent upon unrecognized arteriovenous fistulas which may have been present for as much as ten years. This feature should be kept constantly in mind during the observation of any arteriovenous fistula, with repeated six foot plates of the heart, and operation should be done at the first sign of cardiac stress. The presence of an arteriovenous fistula is a direct indication for operation and none of these cases should be ignored, even though they may cause no symptoms. The local signs of an arteriovenous fistula, of course, are the swelling, pulsation, continuous thrill and bruit, the continuous nature throughout systole and the diastole of the thrill and the bruit being the definite pathognomonic sign of an arteriovenous communication.

Once established, closure of the fistulae by pressure will drop the pulse and give a sharp immediate rise of the blood pressure from the suddenly increased peripheral resistance to the increased blood volume. The changes in three of these cases are shown in Table II. The damming back of blood presumably acts through the depressor nerves in the aorta via the vagus to slow the heart

TABLE II. ARTERIOVENOUS FISTULA; CIRCULATORY EFFECTS OF CLOSURE BY PRESSURE

		RESTING		AFTER CLOSURE	
		PULSE	BLOOD PRESSURE	PULSE	BLOOD PRESSURE
Common Carotid	Case 1	72	128/85	66	140/90
Common Carotid	Case 2	90	128/70	78	145/80
Femoral		62	110/76	48	126/94

and thereby return the blood pressure to normal. These changes are transitory but constitute confirmatory evidence for the presence of an arteriovenous fistula.

An almost constant characteristic of these fistulas is that under observation they usually tend to contract rather than to enlarge. Under these circumstances prolonged observation is almost always indicated. Some small fistulas have been observed to contract and heal spontaneously although this is not a usual course. In this connection Case 12 is reported.

CASE 12.—W. L. was admitted to the hospital fifteen days after a bullet wound of the right upper arm, with both wounds healed, extremely severe pain of the middle humeral region, and a swollen, tense, tender, discolored, 8 by 6 cm. induration just anterior to the mesial wound. This man entered with a combined arteriovenous fistula and false arterial aneurysm; while under observation on the ward, the arteriovenous channel closed. The audible, continuous bruit became a systolic bruit and the palpable pulsation of the systolic thrill decreased in intensity. The pain stayed quite severe. He had a thin radial pulse but with good circulation, and showed evidence of a partial motor and sensory nerve lesion. He was held for five weeks, during which time the systolic bruit became shorter in duration, the pain improved, the induration decreased, and no systolic thrill could be felt. After the local signs had been stationary for several weeks, he was operated upon. After a tape was placed about the axillary artery in the axilla, exploration of the upper arm showed the median nerve embedded in the scar tissue over the false aneurysm. This was freed and retracted, the sac opened and evacuated, and the laceration of the artery was found, freed, and the artery divided and doubly ligated. At the lower pole the artery was found at the point of emergence from the sac to be adherent to the vein where presumably the earlier arteriovenous channel had been present. Both vessels were dissected free and ligated. The nerve was transplanted into a fresh bed away from the area of the sac wall.

A helpful procedure is the operative approach to the subclavian artery by subperiosteal resection of the clavicle.

CASE 13.—J. B. received a bullet wound through the right shoulder and was admitted with a visible fullness and a 5 cm. diameter pulsation just below the lateral portion of the right clavicle in the coracoid area. There was an audible systolic bruit but no thrill. At operation, a long Y-shaped incision was used. Mesially the first portion of the subclavian artery was isolated and a tape placed about it. A subperiosteal resection of the major central portion of the clavicle was then performed and following this an incision through the subclavius muscle bundle in the axis of the artery gave very adequate exposure of its entire course and of the sac. In this case, following proximal and distal arterial section, the vein was ligated also but the sac was not opened. Following operation the patient had a smooth course. He was placed in a Velpeau dressing for ten days, at the end of which time he began to move the arm and increase its function; there rapidly appeared a sense of continuity of the clavicle from the new bone laid down, to palpation. The accompanying roentgenogram shown in Fig. 4, which was taken six weeks later, shows well-established new bone formation and clinically at this time the clavicle was solid. This subperiosteal resection of the clavicle with sacrifice of the resected fragment is a useful procedure when exposure in this area is necessary.

In another patient there was found, in a case of arteriovenous fistula of the common carotid, an associated true arterial aneurysm of the vessel wall adjacent to the fistula.

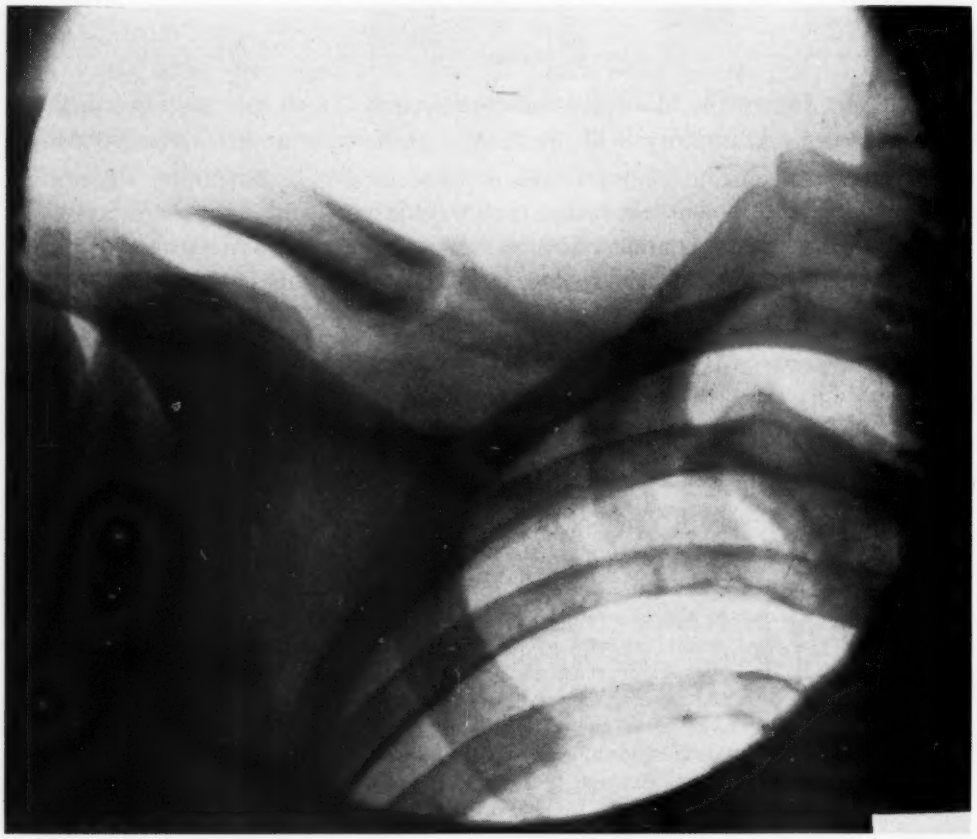


Fig. 4.—Roentgenogram six weeks after resection of clavicle for exposure of subclavian aneurysm showing bone regeneration (Case 13). At this time clavicle was clinically solid and arm function good.

CASE 14.—G. C. received a bullet wound through the neck. The findings on admission showed a pulsating fullness just beneath and lateral to the right sternomastoid muscle. There was a continuous thrill with systolic accentuation readily palpable. There was a loud continuous audible bruit. Closure exercises were done on this man with great care during the two and one-half months he was kept under observation on the ward. He used an apparatus which was devised, similar to the Matas compressor, and also used a padded dowel to interrupt the circulation for intervals which began at two minutes, which was as much as he could tolerate without headache and dizziness at the onset, but were carried up to thirty minutes. Finally, during complete closure of the fistula and the common carotid artery, during a thirty-minute period by the operator, he developed no cerebral symptoms whatever and it was felt safe to proceed with operation. This patient had an arteriovenous channel and, in addition, through the weakened wall of the artery at the same level there had developed a true arterial aneurysm, of which section showed media and intima in the wall of the aneurysm. The tip of this aneurysmal sac was densely adhered to the thyroid gland and consequently it was partially amputated at operation. This represents an unusual complication of this type of injury. The postoperative course was uneventful and the patient was evacuated in excellent condition.

Brief partial notes concerning remaining cases are added here.

CASE 15.—K. S. had a through-and-through mortar shell fragment wound of the left hand with severe hemorrhage controlled by pressure. Marked pain persisted and he was admitted to the hospital fifteen days after injury, when at dressing a severe profuse hemorrhage appeared from a wound of the hypothenar eminence which was controlled by tight pressure. Seven days later, with continuing severe pain, a small pulsating mass was noted under the scar which was very tender. This was treated conservatively with splinting and ten days later marked improvement had appeared and the pulsation was noted to have disappeared. Recovery was uncomplicated. This represented a false aneurysm of ulnar artery which healed spontaneously.

CASE 16.—In L. O., a false aneurysm of the ulnar artery in the palm from a stab wound appeared four days after injury. He was operated upon with isolation and excision of the aneurysm and had a smooth recovery.

CASE 17.—R. L. had a false aneurysm of the mid-portion of the radial artery from a grenade fragment wound at the middle third of the lower surface of the right forearm, which presented two weeks after injury a 3 cm. pulsating mass with a systolic bruit. The wound was allowed to heal completely and a false aneurysmal sac was dissected out and excised with division and ligation of the radial artery above and below the sac. The deep branch of the radial nerve was adherent in the scar at the base of the mass and was freed. There was a small area of anesthesia on the lateral surface of the thumb, which was not influenced by operation.

CASE 18.—G. M. had a false aneurysm of the axillary area artery which developed following a bullet wound through the shoulder with partial defects from injury of all trunks of the brachial plexus. Three weeks after injury a pulsating mass 5 cm. in diameter was found below the outer end of the right clavicle with a short audible systolic bruit. Blood pressure was equal in both arms. He gradually recovered partial motor power in the muscles of the right arm and hand and the aneurysm slowly decreased in size under observation. He was evacuated for operation.

CASE 19.—T. L. had a false aneurysm of the axillary artery from a rifle bullet wound of the shoulder with evidence of pulmonary injury immediately after he was hit. There was a left hemothorax which required two aspirations, and several fractured ribs. He was admitted five weeks after injury with limited excursion of the left chest and a much thickened pleura. The wounds were healed. There was a 4 cm. diameter pulsating mass under the pectoral fold, presenting anteriorly and also in the axilla, systolic bruit and thrill, and moderate tenderness. There was partial median nerve defect and a palpable difference in the radial pulses. Under observation this mass became smaller and the patient was evacuated to the U. S.

CASE 20.—R. C. had an arteriovenous fistula of the common carotid from a wound by a small shell fragment which produced immediate hoarseness and local swelling and pain. Examination two days after injury showed a laceration over the anterior border of the left sternomastoid muscle; a pulsating mass 4 cm. in diameter with a loud continuous bruit and a continuous thrill was felt below this. The trachea was displaced to the right. There was a left recurrent nerve paralysis. Gradual improvement in the local signs and symptoms followed during the one week in which he was observed, although the temporal pulse became progressively weaker. The changes in pulse and blood pressure in this case are indicated in Table II. This man was seen in a forward unit, where it was not possible to retain him for observation and operation.

CASE 21.—L. D. had a 2 cm. pulsating subcutaneous mass in the right supraorbital area which was seen eight months following a blow on the forehead. This was excised and a small arteriovenous cirsoid aneurysmal mass was found.

CASE 22.—In R. J., ten days following a small fragment wound of the anterior part of the right calf, there appeared suddenly a hard, tense nonpulsating mass over this area, extremely painful. Systolic bruit was heard. Prior to this time the possibility of an abscess had been entertained and at operation the sac of a false aneurysm was opened and the artery divided and ligated.

CASE 23.—D. M. had a false aneurysm of the anterior tibial artery which presented a pulsating mass anteriorly just below the knee. It increased gradually in size and became more painful; at operation it was found to originate from the artery just as it came between the tibia and fibula. The sac was excised and the artery divided and ligated. There was partial peroneal nerve defect but the nerve was not explored at the time of operation.

CASE 24.—F. S. received a mortar shell fragment wound of the lower leg. Ten days after injury there appeared sudden swelling of the mesial side of the posterior surface of the leg and a pulsating mass which became painful. Operation was done after fourteen days and a false aneurysm of the posterior tibial artery was found and excised.

CASE 25.—R. L. had recurrent hemorrhage from the posterior tibial artery after receiving a machine gun bullet wound. Fifteen days after injury while in transit he had a sudden severe hemorrhage of the wound. On admission on the seventeenth day there was some continued bleeding and he was operated upon at once. The leg was widely opened and partial laceration of the artery found. It was divided and ligated. He had a smooth subsequent course.

SUMMARY

The interesting features of a group of twenty-five cases of vascular injury seen in the South and Central Pacific campaigns are pointed out.

It is the partial or incomplete laceration of the vessel which prevents spontaneous cessation of hemorrhage, and leads to the complications described—recurrent hemorrhage, false aneurysm, arteriovenous fistula, and arteriovenous aneurysm.

In the handling and evacuation of casualties, these lesions are frequently overlooked in the presence of small clean perforating wounds of the extremities, and only careful examination with auscultation will reveal their presence.

An extensive sterile inflammatory reaction simulating cellulitis is not infrequently a characteristic of false aneurysm, in which case the differential diagnosis is of the utmost importance.

The common tendency of these lesions is toward spontaneous partial healing and decrease in size, but the exceptions in which sudden hemorrhage or rupture occurs make very close observation necessary in cases in which operation is delayed, and emphasize the inadvisability of evacuation, particularly in false aneurysms, before definitive surgery is done. Emergency operation is not infrequently required.

The cases of recurrent delayed hemorrhage from a partially lacerated deep artery demonstrate the dangers of temporizing procedures in such situations and the need for formal exploration, visualization, and division of the artery.

The collateral circulation was found surprisingly effective in this group of young men.

Points concerning the operative procedure are considered and the physiology of arteriovenous fistula is reviewed.

The author wishes to acknowledge the interest and assistance of Captain W. L. Rogers, Medical Corps, U.S.N.R., in the collection and study of this material.

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DERMATOLOGIC ASPECTS OF AMPUTATION STUMPS

WALTER C. HEROLD, M.D., COLORADO SPRINGS, COLO.

PROPER care of the skin of the stump is of great importance. The skin must be able to tolerate the procedures[1] necessary to prepare for prosthesis, otherwise the conditioning will be prolonged and adverse psychologic factors, already severe, will be greatly aggravated. Then, after fitting, it must be able to withstand the daily abuse in an environment for which it was never intended, or the person will be greatly handicapped; when skin disorders begin, use of prosthesis stops.

The consideration of the skin begins immediately after operation. Adhesive tape is usually used to bind the stump and unfortunately, many people are sensitive to it. If it is observed that an irritation develops corresponding to the sites of its application, the tape should be removed. After allowing the inflammation to subside, elastoplast,* an excellent elastic adhesive dressing, could be tried but some patients, sensitive to adhesive tape, are also sensitive to elastoplast. Hence, it is best to change to Scotch tape; this product has a much lower percentage of sensitization. If the postoperative irritation does not conform to the outlines of the tape, it has probably been caused by the antiseptic or the sulfa drugs. That being the case, those preparations should be thoroughly removed and a bland ointment applied until the inflammation subsides.

In the conditioning stage, several procedures are to be avoided lest they delay the toughening of the skin. Cool or warm whirlpool baths[2, 3] are tolerated well if used for short treatments; but hot water and long periods, that is over fifteen minutes tend to soften the skin. For those who advocate massage, the use of a lubricant is warned against; alcohol is permissible if care is taken to avoid chafing the skin. A nicely dried skin becomes toughened and resists infection much better than an oily or soggy skin.

When the skin has been conditioned to receive prosthesis, it is up to the patient to observe strict hygienic measures.[4-6] It must be cleansed daily with soap (nonmedicated) and water and, in addition, must be exposed to the air and sun whenever possible. In a dry climate, particularly in the winter, it is possible by too thorough or too frequent washings to cause severe chapping. A superfatted soap, such as Basis Soap,† or a soap substitute, as Acidolate‡ or Lowila,§ may be beneficial. In this stage, alcohol is advised against[6] since it tends to dry the skin. On the other hand, the use of any oily or greasy substance should be avoided if possible; it predisposes to folliculitis. When the prosthesis is worn, the stump is covered with a daily-laundered

Received for publication, Jan. 21, 1946.

*Supplied by Duke Laboratories, Stamford, Conn.

†Duke Laboratories.

‡Rare Chemicals, Inc., Flemington, N. J.

§Westwood Pharmacal Corp., Buffalo, N. Y.

virgin wool sock[7]; in some few instances the physical irritation properties of wool are sufficient to cause change to white cotton. One or more socks are worn according to the fit in the socket. When too many socks are used, the stump will not bear the proper relations with the prosthesis. An anhidrotic antiseptic dusting powder is recommended; one consisting of 2 per cent aluminum acetate and 10 per cent powdered boric acid in talc is excellent. If the patient tends to perspire freely, ¼ per cent thymol iodide may be added temporarily. "Skin toughenerS" and strong astringents should not be employed[6]; their composition is often questionable as to ingredients and as to the strengths thereof. The changes they produce are usually more detrimental than advantageous. One should know exactly what is being used on the stump and know that it will be beneficial, otherwise its use should not be allowed. If such care is observed, the majority of patients will have no trouble.

The pathologic conditions which do develop may be divided into three groups. The first to be considered is that caused by the stump. A poorly developed scar is an example.[3] If the scar is not pliable, soft, and unattached to the deeper structures, ulceration may develop. Keloid formation, which frequently causes irritation and hence ulcerates easily, is found more often in the sagittal scar than in the transverse.[8] Scars adherent to the bone, even though thin and papery, are less likely to ulcerate because there is no piston action communicated to them; on the other hand, a scar with much muscle tissue between it and the bone has too much motion and often develops trouble. Most authors[5] recommend that only subcutaneous tissue and the fascia of the muscle separate the scar and bone. If ulceration develops in an abnormal scar, in a scar adherent to the bone, or in skin which has become too tight, reamputation is usually indicated,[4] otherwise a full-thickness or pedicle flap may be used. Pinch or Thiersch grafts are employed but are not as satisfactory. Nonsurgical treatment is rarely of lasting benefit.

Folds develop when there is a redundancy of tissue. This may be due to faulty surgery or to a change in the patient's weight. These intertriginous areas make perfect breeding grounds for bacteria. The areas first macerate, then become infected. This may remain an intertrigo[9] or develop into an infectious eczematoid dermatitis which can cover the entire stump. The environment is ideal also for a monilia infection. Skin tabs may cause results similar to those caused by the folds. These underlying conditions require surgical correction.

The second group includes those conditions due to the prosthesis. Friction burns are common, especially when the limb is first fitted. Calluses[10] and areas of lichenification result from unequal distribution of weight or from the bearing of weight on improper areas. Pressure boils and ulcers may develop instead of or associated with calluses. The boils are particularly common on the adductor surface of the thigh as a result of an ill-fitting ischial seat for a thigh amputation. Correction of these conditions depends upon the readjustment of the prosthesis.

The third group consists of those conditions resulting from the association of the stump in the socket. The commonly seen furuncles[6, 10, 11] and folliculitis

especially found in men are in this group, as are the infected sebaceous cysts and infectious eczematoid dermatitis (which is also in the first group). Localized miliaria (heat rash) may develop during warm weather or in warm environment. The stump may become involved in a Trichophyton or Epidermophyton infection; Monilia infection may develop, although this is more probable if folds are present. Treatment for these conditions depends upon the specific instance. In general, soothing antiseptic soaks, that is, boric acid solution, Burow's solution, or potassium permanganate solution, are indicated when used for periods of fifteen minutes' duration three or four times per day, although for massive infection it may be necessary to ignore the softening effect on the skin and use continuously. An antiseptic powder or powdery shake lotion then may be used after each soaking, if there is little or no weeping. Otherwise, it is necessary to follow with an antiseptic incorporated in a water-absorbent ointment base such as Aquaphor or Lassar's paste. Tar is avoided as it is likely to cause follicular irritation. Exposure to air and sunlight is very beneficial and the use of superficial x-ray therapy, ultraviolet light, or cold quartz ray will usually shorten the recovery period.

One important consideration regarding drugs must be discussed. The treatment of the stump may be a rather extended or repeated procedure, thus affording excellent opportunities to develop a sensitivity. For that reason, drugs should be avoided which are high on the list as sensitizers, notably sulfa drugs,[12, 13] mercury, benzocaine, nupercaine, picric acid, butesin picrate, aminobenzene, and chlorbutanol. Instead, such substances may be chosen as boric acid, aluminum acetate, potassium permanganate, or xeroform. Incidentally, penicillin has been reported[14] to have as high a sensitivity as 5 per cent. A chemical contact dermatitis on a stump is often a severe situation which may be very incapacitating and, more important, may lead to the development of additional sensitizations. A sensitivity may develop even to the material of the prosthesis, or, more correctly, to the processing substances in the prosthesis material. A stump, the skin of which has developed multiple sensitivities, is a constant source of trouble.

Generalized skin disorders, such as psoriasis and lichen planus, may develop on the stump. Because of the factor of trauma, the disease may be manifest on the stump and nowhere else. This situation calls into play accurate dermatologic judgment.

In summary, it is noted that the best treatment of possible skin disorders is the unrelenting prophylactic general hygienic care to the stump. Disorders which do develop are divided into three groups; namely, those due to the stump, those due to the prosthesis, and those due to the interrelation of the two. A skin complaint, even though minor, can prevent use of the prosthesis with all the resulting incapacitations.

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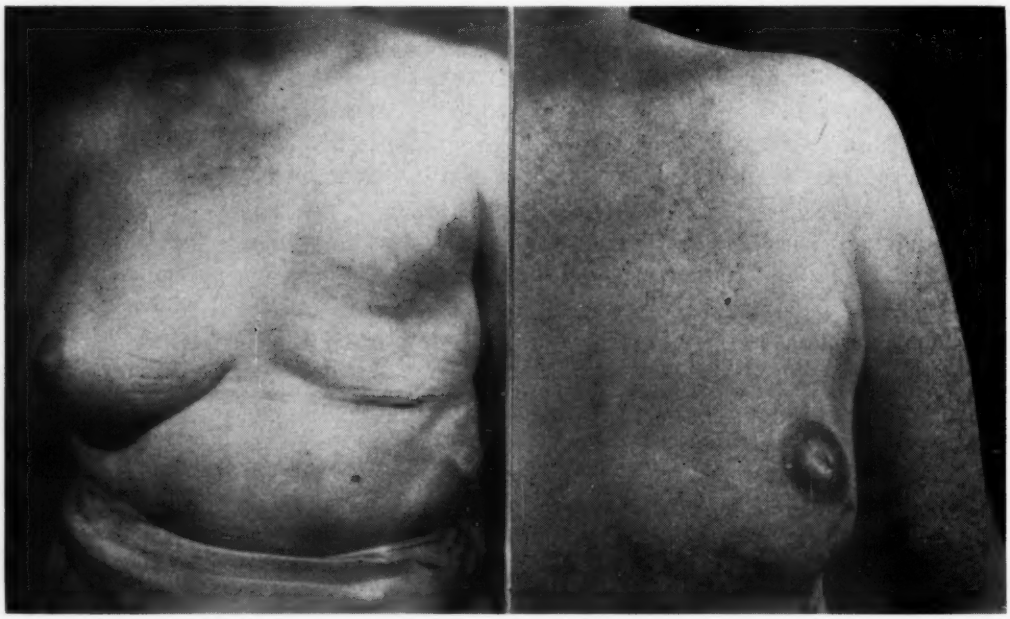
CONSTRUCTION OF PSEUDOAREOLA

MORTON I. BERSON, M.D., NEW YORK, N. Y.

THE areola is usually lost in complete amputation of the breast (Fig. 1, *A*). The breast may be built up by a derma-fat-fascia transplant* to form a normal contour, but will not give an esthetic appearance because of the absence of the areola. I have devised a new method of constructing a projection resembling the nipple in size and shape (Fig. 1, *B*).

A circular incision of the required size is made with a trephine over the apex, through the epithelium, to the derma of the skin (Fig. 2, *A*). The epithelium is undermined from the periphery to 1 cm. of the center, exposing the dermal surface of the skin (Fig. 2, *B*). The loose epithelium, which is shrunken, is stretched, and three identical triangular sections are excised (Fig. 2, *C*).



A. *B.*

Fig. 1.—*A*, Patient before operation. Note complete absence of breast and areola. *B*, Patient after operation. Breast rebuilt with derma-fat-fascia transplant and pseudoareola constructed.

The margins of the triangles are sutured together (Fig. 2, *D*), forming a nipple-like oval projection, with a slight indentation in the center. The base of the epithelium is attached to the derma with fine, interrupted silk sutures. These sutures at the base produce the elevation and shape of a nipple (Fig. 2, *E* and *F*).

Received for publication, Jan. 18, 1946.

*Berson, Morton I.: Derma-Fat-Fascia Transplants Used in Building Up the Breasts, SURGERY 15: 451-456, 1944.

This operation produces a definite nipplelike projection. When the circular area of the derma is epithelized, a dark and mottled shade different from the surrounding skin is produced, thereby giving the appearance of areolar

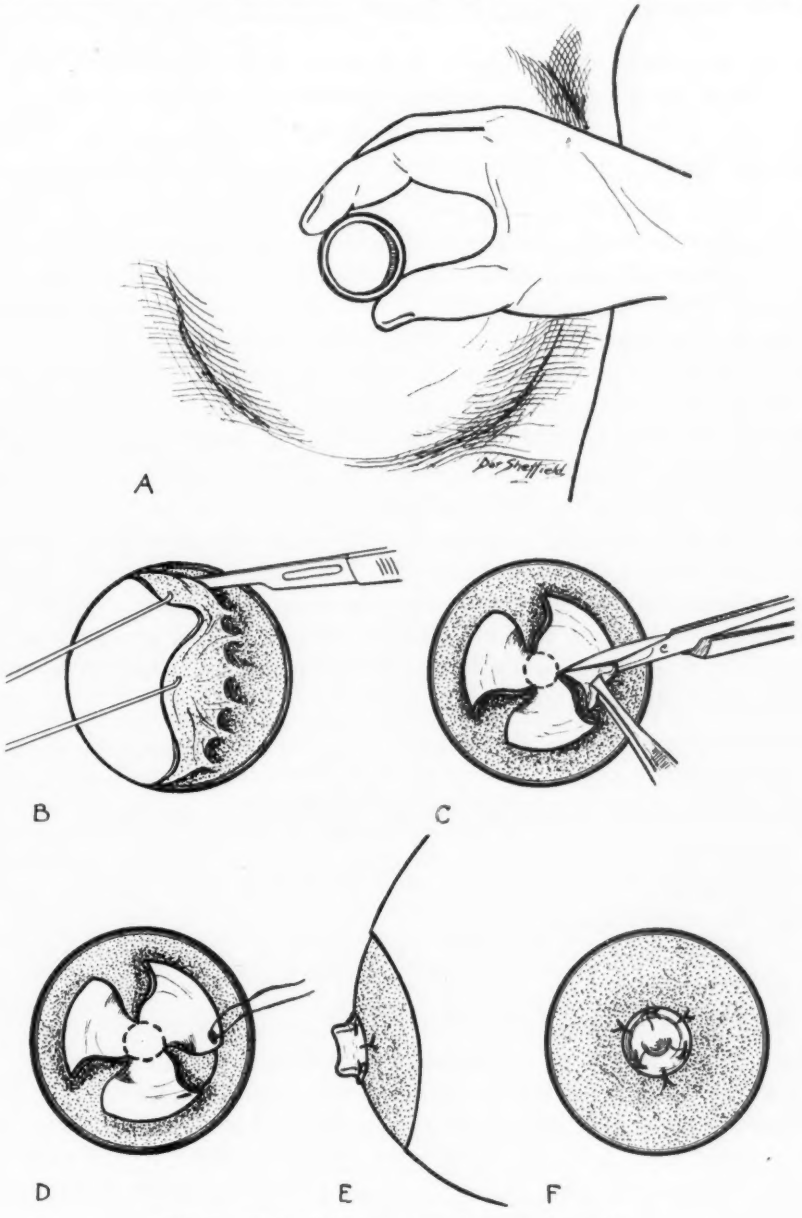


Fig. 2.—Method for constructing pseudoareola.

tissue. The pseudonipple can be constructed at the same time a breast is being rebuilt, and the same method can be used in other cases where function is not a factor.

PRIMARY TORSION OF THE OMENTUM

W. A. Altemeier, M.D., and C. E. Holzer, M.D., Cincinnati, Ohio
(From the Department of Surgery, University of Cincinnati, and the Cincinnati General Hospital)

PRIMARY or idiopathic torsion of the great omentum is a rare pathologic entity which is seldom recognized preoperatively. It occurs frequently enough, however, to require consideration in the differential diagnosis of acute abdominal lesions producing pain. In practically all of the cases reported, the preoperative diagnosis has been acute appendicitis, the symptom complexes of the two conditions being quite similar and often identical.

Torsion of the omentum may be defined as a rotation of the whole or a part of that structure upon its long axis. The extent of the twist may or may not be such that the blood supply of the distal portion is impaired, but it is with the former situation that we are most concerned since it produces the signs and symptoms of an acute abdominal catastrophe.

Two principal types of omental torsion have been described, namely, the primary or idiopathic and the secondary. Primary torsion implies the absence of any recognizable etiologic factor such as hernia, neoplasm, adhesive bands, or inflammatory processes, while torsion in the presence of any such pathologic process is classified as secondary. Of the classifications of omental torsion, that of Teller and Baskin[1] is simple and logical.

A. Primary (pure, true, idiopathic)
   1. Simple torsion
   2. Torsion with herniation of mass through omentum itself

B. Secondary
   1. Hernial
   2. Hernio-abdominal
   3. Abdominal
   4. Pelvic
   5. Combined

The present report is concerned exclusively with the primary type of omental torsion, a lesion much less common than the secondary type. The first case of primary torsion of the omentum was reported by Eitel[2] in 1899. In 1932, Morris[3] studied forty-one such cases collected from 1905 to 1932 and cited six other cases reported by Corner and Pinches in 1905. Lipsett[4] in 1941 reviewed the reports appearing after 1932, collecting ten cases and adding one personal case. Since 1941, six other cases[5-10] have been recorded, bringing the total number of recorded cases to sixty-four. In contrast, the known number of cases of omental torsion of the secondary type is now well over 250, Morris[3] having cited 171 in 1932.

Received for publication, Dec. 20, 1945.

Material.—Within the past year we have operated upon three patients who had gangrene of the omentum caused by unexplained torsion and have found three other similar cases, the patients being treated at the Cincinnati General Hospital in the last twelve years. These six cases, and a seventh reported by Andrus[11] in 1926, to our knowledge constitute the largest group of this type observed in any single clinic.

CASE REPORTS

CASE 1.—C. M., a white man 29 years of age, was admitted to the hospital on Feb. 23, 1933, with a history of abdominal pain of three days' duration. The onset of the pain had been sudden and followed by nausea without vomiting. Several hours after its onset, the pain localized in the right lower quadrant of the abdomen, where it persisted and increased in severity until the time of admission. Two hours before entrance into the hospital, the patient had been given a hypodermic injection of morphine for the relief of the severe pain. There was no history of constipation, diarrhea, or previous attacks, but there was slight burning on urination following the onset of the abdominal pain.

Examination showed a well-developed, well-nourished young man who obviously was in pain. Temperature was 100° F. and pulse 106. Examination of the head, neck, and chest was essentially normal. The abdominal wall moved with respiration. Tenderness localized at McBurney's point, rebound tenderness referred to the same area, and voluntary muscle spasms were easily elicited. There was no tenderness in the costovertebral angles. Rectal examination showed moderate tenderness high on the right side with slight tenderness on the left.

Laboratory examinations showed the urinalysis to be essentially negative and the white blood count to be 20,000 per c.mm.

A diagnosis of acute appendicitis was made and under ether anesthesia, operation was performed through a McBurney incision. No free fluid was encountered. The appendix was found to be bound down by numerous fibrous adhesions, but showed no signs of acute inflammation. Appendectomy was performed in the usual manner and the ligated stump was inverted by means of a purse-string suture of fine black silk. Further exploration through the McBurney incision showed a small amount of sanguineous fluid in the pelvis, but no mass could be palpated there. In the right upper quadrant, an indurated mass was located and delivered into the wound by gentle manipulation. The mass consisted of a discolored and gangrenous portion of the omentum measuring approximately 6 by 6 by 4 cm. The mass had undergone seven complete twists on its neck. The involved area was amputated and the stump transfixed with medium black silk. The wound was then closed in layers without drainage, using catgut as the suture material.

Pathologic examination of the omental mass showed dilatation of the small veins and capillaries with thrombosis of the larger vessels, hemorrhagic extravasation, and extensive necrosis.

The course in the hospital was uneventful, the wound healed kindly, and the patient was discharged on March 4, 1933.

CASE 2.—A. M., a 40-year-old white woman, was admitted to the hospital with a history of pain in the right lower quadrant of four days' duration without nausea or vomiting. The pain had subsided one day after onset, but recurred on the following day. It was of a cramping nature, and persisted until the time of admission. There was no history of constipation but the appetite was poor. There had been no previous similar gastrointestinal symptoms. The patient was also pregnant, the last menstrual period having been three months before.

Examination showed an obese white woman who did not appear acutely ill. Temperature was 99.4° F., pulse 88, and respirations were 24. The pharynx was slightly injected and the heart and lungs were normal. The blood pressure was 135/75. The abdomen showed moderate rigidity of the right rectus muscle, tenderness localized to McBurney's point, and rebound

tenderness referred to the same point. No masses or evidence of hernia were found. The pelvic examination showed an enlarged uterus with a soft movable cervix and moderate tenderness high in the right adnexal region.

The urinalysis was essentially normal and the leucocyte count was 10,200 cells per c.mm.

A diagnosis of acute appendicitis was made, but because of the atypical features of the case, the patient was observed for twelve hours during which the white blood count rose to 12,800 and the pain became more severe.

Operation was then performed through a McBurney incision under general anesthesia. A moderate amount of blood-tinged fluid escaped into the wound from the peritoneal cavity. The appendix was found to be normal in appearance. Appendectomy was done in the usual manner, the ligated stump being inverted by means of a purse-string suture of fine black silk. Examination of the terminal ileum revealed no abnormalities. Both ovaries were normal. A hard mass felt in the right upper quadrant was drawn into the wound with ring forceps. It consisted of a piece of discolored omental tissue measuring approximately 4 inches in diameter by ¾ inch in thickness. It was hemorrhagic in appearance and seemed to be undergoing early gangrenous changes as the result of strangulation produced by twisting of its narrow pedicle. The mass was amputated by dividing the pedicle between Kelly clamps and transfixing the stump with a suture of medium silk. The wound was then closed without drainage, using silk.

Pathologic examination showed the specimen to consist of a flat oval-shaped mass of omentum which was soft and reddish black in color and measured 6.5 by 7.5 by 1 cm. In its upper portion, there appeared to be a 360 degree twist of the narrow neck where the mass had been amputated. Distal to the neck the mass was gangrenous. The appendix was normal.

The patient's course in the hospital was uneventful. The wound healed well and she was discharged on Sept. 22, 1936.

CASE 3.—H. A., a 34-year-old white man, was admitted to the hospital on March 22, 1942, with a history of left-sided abdominal pain of three days' duration. The pain of gradual onset became generalized and cramping in nature within twenty-four hours. On the day before admission the discomfort localized in the right lower quadrant of the abdomen and was exaggerated by deep breathing or movements. Appetite was poor, but there was no vomiting. He had had no previous similar attacks.

Physical examination showed a well-nourished white man who appeared to be in moderate pain. Temperature was 100° F., pulse 106, and respirations were 25. The examination of the head, neck, and chest was not remarkable. There was marked tenderness localized over McBurney's point and laterally above the crest of the ileum with rebound tenderness referred to the same area. No abdominal masses were palpated. The abdomen was not distended and peristaltic sounds were of diminished intensity. Rectal examination revealed moderate tenderness high on the right side.

Laboratory data revealed urinalysis negative. The white blood count was 17,700.

The diagnosis of acute appendicitis was made and under general anesthesia, operation was performed through a McBurney incision. Upon incision of the peritoneum, thin bloody fluid escaped into the wound. Examination of the appendix showed its surface vessels to be slightly injected, but otherwise the structure was normal. The mesenteric nodes of the terminal ileum were moderately enlarged. No Meckel's diverticulum was found. Appendectomy was done in the usual manner, the ligated stump being inverted by means of a purse-string suture of fine black silk. Further exploration revealed an indurated mass in the right lumbar gutter. This was delivered into the wound and found to be a mass of omentum discolored by hemorrhage and early gangrene. Its narrow pedicle was found to be acutely twisted upon itself. The pedicle was divided between clamps and transfixed with fine black silk, the mass being removed in this manner. The wound was then closed without drainage using fine black silk as suture material.

Pathologic examination of the omental tissue showed extensive extravasation of blood. Several large blood vessels present in the section showed no evidence of thrombosis. Fibrinopurulent exudate was present along the serosal surface on one margin of the section.

The patient's course in the hospital was uneventful. The wound healed per primam and the patient was discharged on March 29, 1942.

CASE 4.—H. A. S., a white man 30 years of age, was admitted to the hospital on May 31, 1944, with a history of severe pain in the right lower quadrant of the abdomen of approximately twenty-three hours' duration. The onset of the pain had been quite sudden, but was not associated with nausea or vomiting. The pain was exaggerated by walking, deep breathing, and coughing. There was no history of constipation or diarrhea.

Examination showed a short, obese white man who obviously was having severe pain. Temperature was 99.4° F., pulse 16, and respirations were 24. The examination of the head, neck, and chest was essentially negative. The abdominal wall was thick and protruded beyond the level of the thorax. No obvious masses were palpable. There was marked tenderness associated with rebound tenderness and moderate rigidity in the upper portion of the right lower quadrant of the abdomen. Psoas spasm and costovertebral tenderness were absent. Auscultation of the abdomen showed the presence of normal peristaltic sounds. There was no evidence of hernia. Rectal examination was essentially negative.

Laboratory findings showed the white blood count to be 8,050 with 58 per cent polymorphonuclear leucocytes, 35 per cent lymphocytes, 2 per cent monocytes, 3 per cent eosinophiles, and 2 per cent basophiles. The hemoglobin was 96 per cent and the red blood count was 4,480,000. Urinalysis was essentially normal.

A diagnosis of acute appendicitis was made and operation was performed through a McBurney incision under general anesthesia consisting of cyclopropane and ether. On opening the peritoneal cavity, a small amount of bloody serous fluid escaped into the wound. The appendix was visualized with some difficulty and was found to be retrocecal in position, being bound down by fibrous adhesions. It was removed in the usual manner, the ligated stump being inverted by means of a purse-string suture of fine black silk. Further exploration through a Weir extension revealed the terminal ileum and mesentery to be normal. There was no evidence of a Meckel's diverticulum. A discolored portion of the omentum, approximately 6 by 8 cm. in size, was found in the upper part of the right lower quadrant of the abdomen. It was free and unattached to contiguous structures. It was hemorrhagic and partially gangrenous as a result of torsion of its narrow pedicle. The gangrenous mass was removed after division of the base and transfixion of the stump with fine black silk sutures. The abdominal wound was closed in layers without drainage using black silk sutures.

Pathologic examination showed dilatation of the blood vessels with extravasation of red blood cells throughout the fatty tissue. Thrombosis of many of the vessels had occurred and areas of early necrosis were evident.

Postoperatively the patient's course was uneventful. Temperature rose to 101.2° F. within twelve hours after operation and then gradually fell, reaching normal forty-eight hours later. The wound healed per primam and he was discharged from the hospital ten days after operation.

CASE 5.—J. D., a colored man 46 years of age, was admitted to the hospital on April 30, 1945, with a history of abdominal pain of three days' duration. The onset of pain was gradual and occurred while the patient was shoveling coal. The pain gradually increased in intensity, causing the patient to walk in a bent-over position and forcing him to quit work the day before admission to the hospital. He complained of nausea, but no vomiting, constipation, or diarrhea. There had been no previous similar attacks and his health had been excellent.

Examination showed a robust and muscular colored man who did not appear to be acutely ill. Temperature was 98.6° F., pulse was 80, and respirations were 20. Examination of the head, neck, and chest was essentially normal. Moderate rigidity with voluntary muscle spasm was present in the right lower quadrant of the abdomen. Point tenderness was elicited over McBurney's point and rebound tenderness was referred to the same area. There was no tenderness in the flank or evidence of hernia. Rectal examination showed moderate tenderness high on the right; no tenderness on the left. Laboratory examination showed the urinalysis to be negative and the white blood count to be 7,050.

Diagnosis of probable acute appendicitis was made and the patient was admitted to the hospital for further observation. The white blood count was repeated in three hours and found to be 10,000 at this time. Operation was decided upon and performed through a small transverse incision under spinal anesthesia. The appendix was located and found to be perfectly normal. No abnormalities in the terminal ileum or its mesentery were noted. No Meckel's diverticulum was present. A firm, immovable, irregular mass was palpated in the right paracolic gutter in the lower portion of the right upper quadrant. The mass was apparently attached to the colon. The right rectus muscle was reflected medially, permitting direct visualization of the mass which consisted of a 3 by 2 by 1 cm. portion of dark, red, hemorrhagic omental tissue attached to the remainder of the omentum by a narrow pedicle which was acutely twisted upon itself. The tip of the omental mass was also attached to the anterior surface of the ascending colon by a slender fibrinous adhesion. The adhesion and the pedicle of the mass were individually ligated with fine black silk and divided. Appendectomy was done in the usual manner, the ligated stump being inverted by means of a purse-string suture of medium black silk. The wound was then closed with silk without drainage.

Pathologic examination showed that the omental tissue consisted of degenerated fat cells and fibrous tissue which was infiltrated by plasma cells, polymorphonuclear leucocytes, and lymphocytes. There was extravasation of the red blood cells. No normal architecture of the omentum remained.

The patient's course in the hospital was uneventful and the wound healed per primam without evidence of infection. He was discharged from the hospital on May 9, 1945. He was seen later on May 16, 1945, at which time he had no complaints and the wound was found to be well healed.

CASE 6.—M. L. S., a 36-year-old white woman, was admitted to the hospital on July 12, 1945, with a history of abdominal pain of twenty-four hours' duration. The onset of the pain was sudden and occurred fifteen minutes after lunch. The pain was severe, constant, and localized over an area of moderate size in the right lower quadrant of the abdomen. There had been anorexia and nausea but no vomiting. Urinary frequency was present beginning with the onset of pain. She had undergone three previous operations, including a spinal fusion for tuberculosis of the lumbar spine at the age of 19. No evidence of tuberculosis of the lungs was demonstrated by physical or roentgenologic examination.

Physical examination revealed a white woman who appeared acutely ill and very pale. Temperature was 99.6° F., pulse 90, and respirations were 24. The skin was dry and sallow. A scar was present over the anterior aspect of the left leg and over the lumbar spine. Examination of the head and neck was essentially negative. The lungs were clear to percussion and auscultation and a loud systolic murmur was heard over the precordium. Heart sounds were otherwise of good quality, rate, and rhythm. There was slight distention of the thick abdominal wall, marked tenderness and rigidity at McBurney's point, rebound tenderness referred to the same area, and hypoperistalsis. No masses were palpated. Pelvic and rectal examinations were not remarkable. The lumbar spine was rigid but no tenderness was elicited. Laboratory examinations showed the urinalysis to be negative and the leucocyte count to be 12,900.

The diagnosis of acute appendicitis was made and operation was performed through a McBurney incision. The appendix was easily identified and found to be grossly normal. A considerable amount of thin, bloody, serous fluid was present in the abdominal cavity. A small corpus luteum cyst of the right ovary was found to be bleeding. This was closed by fine silk sutures. On further exploration through a Weir extension, a portion of the omentum 4 by 8.5 cm. was found in the upper portion of the right lower abdominal quadrant. This omental mass was discolored by hemorrhage and early gangrene, which were the direct result of torsion of its narrow pedicle. The area of strongulated omentum was removed at the point of torsion and the resultant stump transfixed by a medium silk suture. The operative wound was then closed in layers without drainage, using fine black silk sutures.

Pathologic examination of the portion of strangulated omentum showed marked dilatation of the veins and capillaries with diffuse hemorrhage throughout the fatty tissue.

The postoperative course was entirely uneventful. The wound healed and she was discharged from the hospital on the eighth postoperative day.

Analysis.—Our patients varied in age from 24 to 46 years. As reported by Morris,[3] this lesion has occurred in patients between the ages of 30 and 50 years in the majority of instances. Men were most commonly affected, and the patient was usually described as robust or obese. Four of our patients were men and all were of robust or obese habit.

TABLE I

CASE NUMBER	AGE (YEARS)	SEX	RACE	OCCUPATION
1	29	Male	White	Unknown
2	40	Female	White	Housewife
3	24	Male	White	Waiter
4	30	Male	White	Hospital orderly
5	46	Male	Negro	Laborer
6	36	Female	White	Waitress

Hernia can be excluded as an etiologic factor in this series since the history, physical examination, and operation failed to reveal the existence of this condition. It is also unlikely that any previous acute inflammatory process contributed to the development of the omental torsion. Abdominal pain was the initial symptom of all of the cases beginning in the right lower quadrant in four, in the left lower quadrant in one, and throughout the abdomen in the sixth with radiation to and localization in the right lower quadrant later. It is perhaps of etiologic significance that the onset of the pain was usually associated with some strenuous activity, this observation having been made frequently in the past. In this connection Uzategui[7] makes the rather curious statement that omental torsion is more frequent in acrobats than in any other persons.

The duration of symptoms was three or more days in four of our cases, the range being from one to four days. None of the patients appeared especially ill at the time of the initial examination, and it was a frequent observation that the general appearance and lack of prostration of these patients was not in keeping with the existence of an acute intra-abdominal process of several days' duration. Nausea or anorexia, but no vomiting, occurred in each patient. This phenomenon is not in accord with the usual sequence of events in acute appendicitis.

TABLE II

CASE NUMBER	DURATION OF SYMPTOMS (DAYS)	INITIAL SYMPTOM	DESCRIPTION OF PAIN			ASSOCIATED SYMPTOMS
			INTENSITY	INITIAL LOCATION	LOCALIZATION	
1	3	Pain	Moderate	Generalized	RLQ	Nausea, mild dysuria
2	4	Pain	Moderate	RLQ	RLQ	Anorexia
3	3	Pain	Moderate	LLQ	RLQ	Anorexia
4	1	Pain	Severe	RLQ	RLQ	Nausea
5	3	Pain	Moderate	RLQ	RLQ	Profuse diaphoresis, nausea
6	1	Pain	Moderate	RLQ	RLQ	Nausea, slight urinary frequency

The results of the physical and laboratory examinations revealed no distinguishing characteristics which indicated any diagnosis other than "acute appendicitis." The presence of fever, tenderness at McBurney's point, muscular rigidity in the right lower quadrant of the abdomen, rebound pain referred to McBurney's point, decreased intestinal peristaltic activity as determined by auscultation, and leucocytosis indicates the marked similarity of the clinical pictures of the two conditions. In no instance was a mass felt on palpation of the abdomen or on rectal examination. Tenderness in the cul-de-sac of Douglas was elicited in four of the six cases.

TABLE III

CASE NUMBER	TEMPERATURE (DEGREES F.)	PULSE	TENDERNESS			RIGIDITY	RECTAL EXAMINATION	WHITE BLOOD COUNT	PREOPERATIVE DIAGNOSIS
			LOCATION	INTENSITY	REBOUND				
1	100.0	106	McBurney's point	Mild	Present	None	Tenderness on right	20,000	Acute appendicitis
2	99.4	88	McBurney's point	Moderate	Present	Moderate	Tenderness on right	10,200	Acute appendicitis
3	100.0	---	McBurney's point	Moderate	Present	------	Tenderness on right	17,700	Acute appendicitis
4	99.4	116	R.L.Q.	Severe	Present	Moderate	Negative	8,050	Acute appendicitis
5	99.6	80	McBurney's point	Moderate	Present	Moderate	Tenderness on right	7,050	Acute appendicitis
6	99.6	90	McBurney's point	Severe	Present	Severe	Negative	10,000 12,900	Acute appendicitis, possible tuberculous ileocolitis

A preoperative diagnosis of acute appendicitis was made in every instance, resulting in exploration of the abdomen through a McBurney incision in five of the cases and through a short transverse incision in the sixth. The operative findings and procedures were significantly similar and, in fact, practically identical in all. The presence of thin, sanguineous fluid in the general peritoneal or pelvic cavities of five patients led the respective surgeons to search further than the normal-appearing appendix for the responsible lesion. This search extended first to the ileum and its mesentery and next to the pelvic viscera. In one case a hemorrhagic corpus luteum of the right ovary was found, but was con-

TABLE IV

CASE NUMBER	INCISION	PERITONEAL FLUID	OPERATIVE PROCEDURE	RESULT
1	McBurney	Bloody	Excision of omental mass; appendectomy	Uneventful convalescence
2	McBurney	Bloody	Excision of omental mass; appendectomy	Uneventful convalescence
3	McBurney	Bloody	Excision of omental mass; appendectomy	Uneventful convalescence
4	McBurney with Weir extension	Bloody	Excision of omental mass; appendectomy	Uneventful convalescence
5	Transverse	None	Excision of omental mass; appendectomy	Uneventful convalescence
6	McBurney with Weir extension	Bloody	Excision of omental mass; appendectomy	Uneventful convalescence

sidered incapable of producing the amount of bloody fluid present in the peritoneal cavity. As a last resort, each surgeon, palpating the upper portions of the abdomen as well as possible through the limited incision, felt a mass in the right paracolic area or in the lower part of the right upper quadrant. The mass was grasped carefully with a forceps and gently delivered into the wound. Each lesion consisted of a small portion of the lower right border of the great omentum which had become twisted upon a narrow pedicle. The masses were all small, varying from 3 by 3 cm. to 6 by 6 cm. in size and showed evidence of thrombosis of the blood vessels with necrosis. In one case, the gangrenous omentum was loosely attached to the ascending colon by fresh, delicate fibrinous adhesions. The gangrenous portion was amputated and its pedicle ligated. In addition, appendectomy was done and the abdominal wound closed in layers without drainage. The postoperative courses of all of the patients were uneventful, and no complications developed subsequently.

DISCUSSION

There has been much speculation regarding the etiology of omental torsion. The association of torsion with hernia, omental tumor or cyst, and inflammatory or postoperative adhesions is more easily understood. However, these factors are absent in primary omental torsion, and the etiology is essentially unknown. A number of theories have been advanced and several of these are of interest. It is a common clinical observation[3] that the right side of the omentum is the larger and the more mobile portion which hangs down into the right iliac fossa, while the lower left border usually lies higher in the left hypochondrium. The right side, therefore, would be more likely to be involved by exaggerations of the normal movements of the omentum. In practically all of the cases reported, torsion developed in the right inferior portion of the omentum.

Teller and Baskin[1] observed that torsion occurred more frequently in obese individuals. Infiltration with fat tends to increase the weight and length of the omentum and accessory projections usually found along its right border. The tendency to pedicle formation increases as the omentum becomes heavier and longer, thus predisposing to torsion.

Payr[12] pointed out that hemodynamic forces may be important in the etiology of omental torsion. Due to a change in the relative position of the omental mass, stasis in the tortuous veins may result in their distention and elongation in relation to the relatively straight arteries. This produces an unequal distribution of forces within the substance of the omentum favoring rotation about the more rigid arteries as an axis.

Sellheim[12] was of the opinion that rotary movements of the whole body, as in various forms of physical activity, transmitted to the viscera and particularly the omentum. In support of this theory is the observation that the onset of symptoms was associated with some vigorous physical activity.

It is obvious that no single theory adequately explains the production of torsion of the omentum in every instance and it is likely that many factors play a part often in the same case. This study has failed to reveal any definite cause for the omental torsion occurring in our cases. However, the observation that

all of the patients were moderately obese and that most were engaged in some rather vigorous activity lends support to the theories of Teller and Sellheim. Obesity and strenuous physical activity are probably important predisposing factors in the pathogenesis of omental torsion, although the true cause is probably still unknown.

The diagnosis of torsion of the omentum has been made preoperatively in only a few instances in the past and in none of our cases. The clinical picture has been essentially indistinguishable from that of acute appendicitis except in those few cases in which a mass became palpable early in the course of the illness before abscess formation would be expected in appendicitis. Torsion of the omentum may be suspected when a person, usually a man in the third or fourth decade, is seized with rather sudden generalized abdominal pain which rapidly becomes localized in the right abdomen, usually the lower quadrant. The pain, usually mild at the onset, increases in severity. The progression of the symptoms, however, is usually less rapid than in appendicitis. Nausea or anorexia is present but vomiting is seldom a prominent feature. Only these ill-defined characteristics may suggest the presence of omental torsion rather than acute appendicitis, the laboratory and physical examinations usually revealing findings quite compatible with the latter diagnosis. It should be emphasized that no practical importance is attached to a preoperative diagnosis of omental torsion since both the nature of the lesion and the similarity of the signs and symptoms to those of acute appendicitis make surgical exploration of the abdomen mandatory.

At this clinic, operation for acute appendicitis is carried out through a McBurney incision, and it is of significance to note that it was unnecessary to make a second abdominal incision in order to palpate and deliver the omental mass although a Weir extension was made in two instances to facilitate the exploration. The location of the mass in the right portion of the omentum, usually just above the level of the incision, supports the opinion of Morris[3] that the right half of the omentum is longer and more subject to torsion.

While it is relatively unimportant to differentiate torsion of the omentum from other acute processes in the right iliac fossa preoperatively, it is essential that the surgeon be familiar with this entity and that he search for it when laparotomy fails to reveal one of the more common causes of acute abdominal pain or serosanguineous peritoneal fluid. Torsion of the omentum is strongly suggested by the presence of unexplained serosanguineous fluid in the abdominal cavity.

Excision of the involved portion of the omentum with careful ligation of the vessels in the pedicle is the treatment of choice for this condition. Bressan[8] emphasized the importance of resection of the structure at a level above the involved tissue in order to prevent spread of thrombosis proximally to involve the vessels of the stomach and colon, but it seems to us that such a possibility is unlikely and of little practical importance.

The mortality resulting from torsion of the omentum is extremely low, only one death having been reported. The prognosis for a rapid, complete, and uneventful recovery is excellent.

SUMMARY

Six previously unreported cases of primary or idiopathic torsion of the omentum have been studied in an attempt to determine whether or not this lesion has any distinguishing clinical features which may be of diagnostic significance. A review of the literature reveals only sixty-four previously reported cases, and the present series of six brings the total to seventy. The theories pertaining to the etiology, the surgical significance, the treatment, and the prognosis of this condition have been discussed and evaluated.

CONCLUSIONS

1. Idiopathic torsion of the omentum is a rare condition, to our knowledge only sixty-four previous cases having been reported in the literature.

2. Its cause is obscure, but adiposity and strenuous physical activity apparently are predisposing factors.

3. The condition is usually confused with acuté appendicitis, but should be suspected in an obese or robust patient complaining of pain of several days' duration in the right lower quadrant of the abdomen, beginning during strenuous physical activity and being unassociated with vomiting.

4. The treatment of choice is excision of the gangrenous portion of the omentum with ligation of the vessels of its pedicle. The prognosis is excellent.

5. Primary torsion of the omentum should be looked for when laparotomy for acute appendicitis reveals a normal appendix and no other explanation of the clinical signs and symptoms, particularly the presence of sanguineous intraperitoneal fluid. A careful search is usually necessary to demonstrate the lesion which is usually located in the right paracolic gutter or lower portion of the right upper quadrant of the abdomen.

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SIMULTANEOUS CHOLECYSTENTEROSTOMY AND CHOLEDOCHOENTEROSTOMY

Experimental Study*

Douglas R. Morton, M.D., Earl Hathaway, M.D., and Alexander Brunschwig, M.D., Chicago, Ill.

IN TWO patients subjected to one-stage pancreatoduodenectomy there was no obstruction to the common bile duct and, therefore, the latter was not dilated. In one instance the operation was performed because of invasion of the head of the pancreas by carcinoma of the pyloric portion of the stomach. In the other patient, a large carcinoma of the third portion of the duodenum invading the inferior margin of the head of the pancreas was resected. The problem of dealing with the normal-sized transected common duct was met by implantation of it into the first long loop of jejunum and a few centimeters

Table I. Implantation of Upper Segment of Transected Common Bile Duct Into Gall Bladder

DOG	SURVIVED OPERATION	FINDINGS
869	59 days, killed	Abdomen negative; upper stump of choledochus obliterated in gall bladder wall
16	45 days, killed	Same as in Dog 869
9	61 days, killed	Abdomen negative, cholecystduodenostomy functioning; common duct implanted into gall bladder patent

Table II. Simultaneous Choledochoduodenostomy and Cholecystoduodenostomy

DOG	SURVIVED OPERATION	FINDINGS
606	32 days, peritonitis	Abscess at site of operation, cholecystduodenostomy functioning, lower segment of choledochus obliterated
377	104 days, killed	Abdomen normal, patent cholecystduodenostomy, patent choledochoduodenostomy
112	106 days, killed	Same as in Dog 377
604	111 days, killed	Same as in Dog 377
603	124 days, killed	Same as in Dog 377
3	124 days, killed	Same as in Dog 377
381	125 days, killed	Same as in Dog 377
542	126 days, killed	Abdomen negative, lower segment of choledochus obliterated, cholecystduodenostomy functioning

distally a cholecystojejunostomy was performed. Simple ligation of the transected common duct does not appear to be the procedure of choice since experience has now revealed that in man, at least, the ligated common duct may open later with fatal bile peritonitis or development of a deep abscess even though a functioning cholecystojejunostomy is present. It must be admitted, however, that in these instances the common duct was enlarged.

The first patient alluded to previously was well eleven months after operation and has resumed his usual occupation, although recently a metastasis was excised from the lumbar muscles. The second patient succumbed three months

Received for publication, Dec. 22, 1945.

*This study was conducted under the Charles and Mary F. S. Worcester Memorial Fund, University of Chicago.

after discharge and necropsy was not obtained; presumably death was due to recurrences.

The question arises whether or not the implanted normal-sized common bile duct remains patent in the presence of a functioning cholecystojejunostomy. If cicatricial obliteration occurs, then implantation into the bowel would seem to be a needlessly complex procedure. It would appear that the transected normal-sized common duct could be implanted into the gall bladder by means of a small stab wound. This would obviate the presence of a free ligated common duct which might later open with escape of bile into the peritoneal cavity.

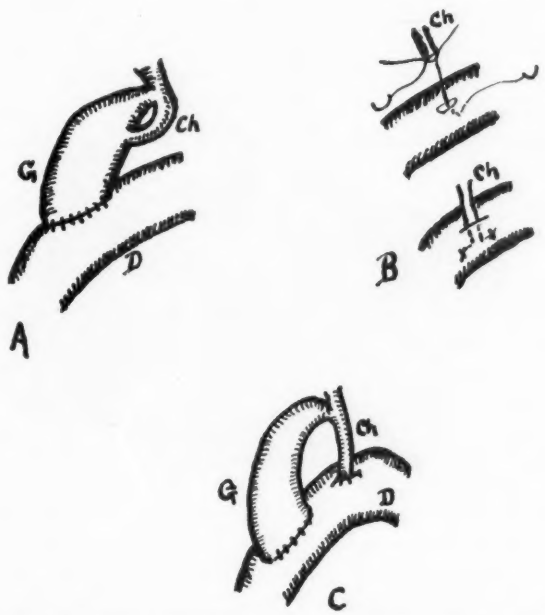


Fig. 1.—*A*, Showing cholecystoduodenostomy; *G*, gall bladder; *D*, duodenum; *Ch*, upper segment of transected common duct has been implanted into the gall bladder.

B, Showing method of implanting *Ch*, common duct into small bowel. Sutures are placed through edges of the duct and then passed through bowel wall and tied; one or two sutures are placed between serosa of bowel and serosa of common duct after the latter has been tied into the bowel.

C, Showing completed simultaneous cholecystoduodenostomy and choledochoduodenostomy.

This procedure was carried out in three dogs, and appeared feasible (Fig. 1, *A*). In one, the stump of common duct turned into the gall bladder did not become obliterated but remained patent (see Table I).

Another series of animals was subjected to simultaneous choledochoduodenostomy and cholecystoduodenostomy to observe if subsequent cicatricial obliteration of the common duct would occur. The common duct was transected near the duodenum and the lower segment was ligated. The upper end of the transected common duct was then implanted into the second portion of duodenum. A small stab wound was made through the wall of the bowel and a silk suture inserted into each margin of the duct. The threads were brought through the duodenal wall from within outward on each side of the stab wound and tied. Interrupted sutures were placed between common duct and duodenal serosa (Fig. 1, *B* and *C*). A cholecystoduodenostomy was performed just distal to the above anastomosis.

The results are summarized in Table II. In two instances the choledochus above the site of duodenal implantation cicatricized into a dense fibrous cord. In one instance (Dog 606) this may have been due to abscess formation at the site of operation. Necropsy revealed no gross evidence of biliary leakage. In six instances both choledochoanastomoses and cholecystoanastomoses remained patent and were apparently functioning.

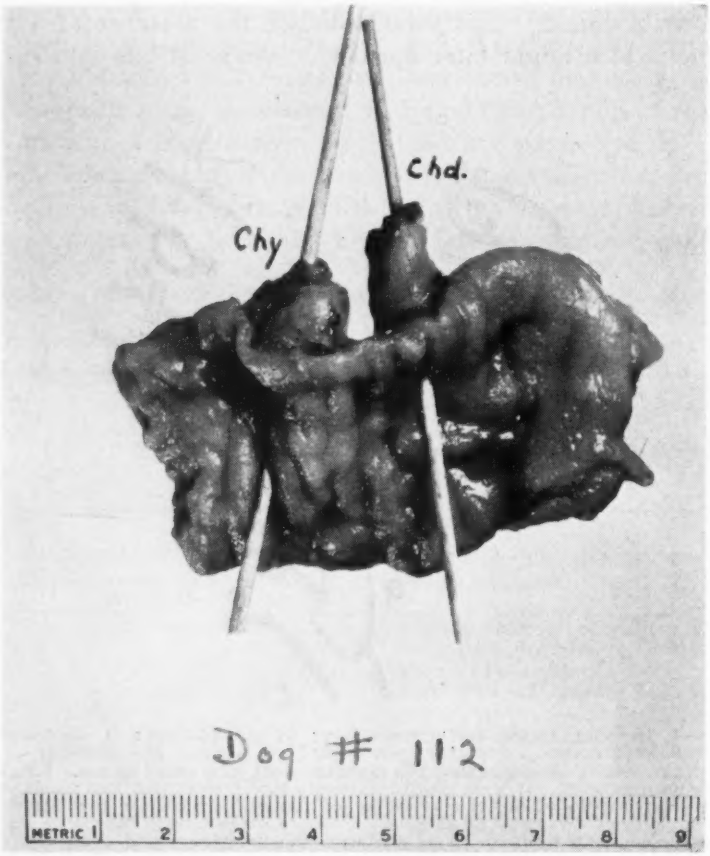


Fig. 2.—Photograph of specimen from Dog. 112 (106 days) showing patency of *Chy*, cholecystduodenostomy and *chd*, choledochoduodenostomy. Wooden probes are passed through each anastomosis.

SUMMARY

Simultaneous implantation of transected common duct and gall bladder into the duodenum was carried out in dogs. In six of eight animals both the cholecystoanastomoses and choledochoanastomoses remained patent. In two instances the implanted choledochus became obliterated by cicatrization. A method is thus suggested for dealing with the normal-sized common duct if pancreatoduodenectomy is performed in the absence of dilatation of the common duct (in which situation a choledochojejunostomy is performed). A satisfactory alternate procedure would appear to be implantation of the transected common duct into the gall bladder, the latter being utilized for cholecystojejunostomy. Simple ligation of the upper stump of common duct in pancreatoduodenectomy is to be avoided.

DISSECTING DIVERTICULITIS OF THE COLON

SAMUEL E. COHEN, M.D.,* ELMIRA, N. Y., AND
BEN L. MATTHEWS, M.D.,† BINGHAMTON, N. Y.
(From the Divisions of Pathology and Surgery of the Binghamton City Hospital)

WE WISH to call attention to a kind of diverticulum which heretofore has not been described. The usual forms represent an extrusion of a lumen through its retaining wall whereby the sacculation projects beyond the serosal surface of the bowel. In the dissecting (intramural) type a herniation of the lumen occurs into the wall of the gut and then this sacculation burrows its way along the wall. The analogy with dissecting aneurysm is apparent, although the mechanisms are not identical.

The basis for this report is furnished by a specimen removed from a 60-year-old man who underwent a laparotomy with the preoperative diagnosis of obstruction in the descending colon due to carcinoma. The resected specimen comprised 16.5 cm. of the sigmoid and was 6 cm. in diameter. The serosal surface was deeply injected, and the appendices epiploicae were thickly edematous. On external palpation of the specimen the lumen was noted to be eccentric due to unequal thickness of the walls. On section, the thinner wall measured 1.5 cm., its layers appeared stratified, and were hypertrophic and edematous. The thicker portion of the wall measured 4 cm. and was infiltrated with dense, white tissue. The mucosa was smooth, intact, and in places hemorrhagic; the mucosal folds were swollen and coarse. The initial line of incision to expose the lumen of the specimen fortuitously exposed a cavity in its thicker portion (Fig. 1). Here the wall had become separated into two layers by a space which extended most of the length and part of the circumference of the specimen. A few centimeters from the oral end, a round mammilla-like stoma, 0.5 cm. in diameter, was present which easily admitted a probe and communicated directly with the intramural sinus (Figs. 1 and 2, *A*). This cleavage extended in the long axis of the specimen for a distance of 9 cm. and was 2 to 3 cm. in width. Approximately in its middle third, the cavity disclosed an accessory space extending laterally and in a circular manner around a portion of the wall. This lateral projection ran parallel to the transverse diameter of the specimen for a distance of 2.8 cm. (Figs. 1 and 3). At its distal end, the resected sigmoid revealed one larger and two smaller ordinary diverticula (Fig. 2, *B*), one of which was separated from the intramural dissecting diverticulum by a thin septum.

Microscopically, the cavity space was lined with surfaces made up of chronic vascular granulation tissue which showed marked infiltration with polymorphonuclear leucocytes. An occasional remnant of mucosal glands was still present. The sinus space was situated outside of the circular layer of muscle.

Received for publication, Jan. 24, 1946.
*Pathologist to the Arnot-Ogden Memorial and St. Joseph's Hospitals, Elmira.
†Attending Surgeon, Binghamton City Hospital.

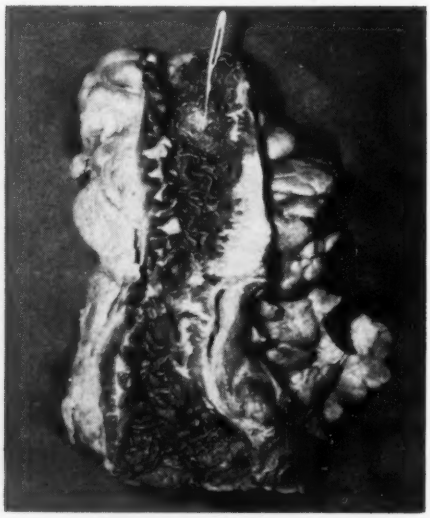
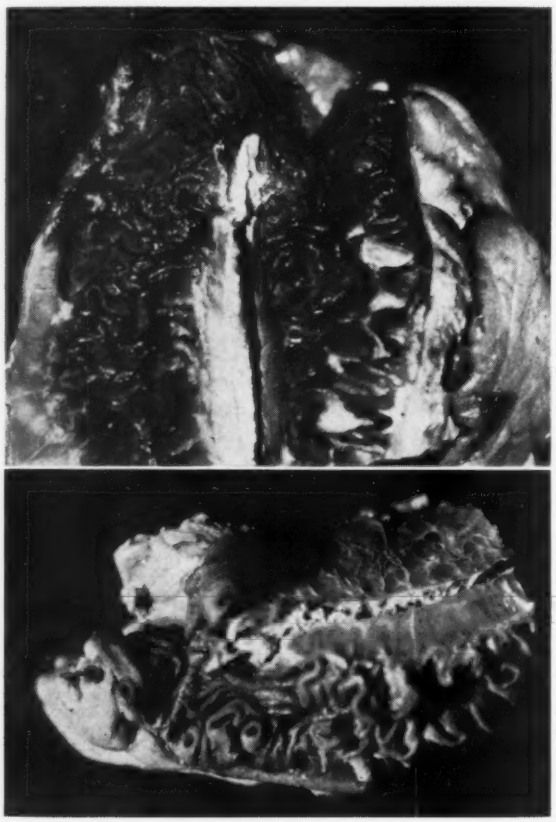


Fig. 1.—Resected specimen of sigmoid with a cloaca-like stoma (admitting the probe) and a portion of the lateral, circumferential component of the intramural dissecting diverticulum.

A.

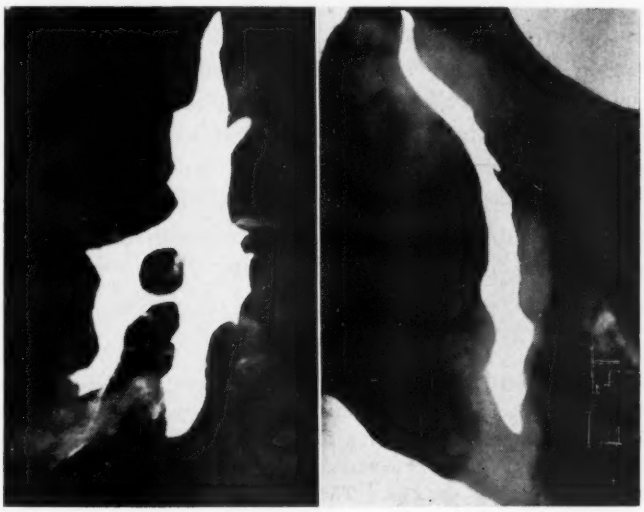


B.

Fig. 2.—*A*, Oral end of the diverticulum opened. *B*, Aboral end of the specimen with three lesser diverticula and the major lesion.

The inflammation extended into the adjacent adipose but was of mild character. At the apex of the main diverticulum other islands of mucosal glands were noted representing cross sections of the diverticula noted grossly (Fig. 4).

Interpretation and Pathogenesis of the Clinical Course.—The patient had a diverticulosis comparable to that which is quite common. One of these saccu-



A. *B.*

Fig. 3.—The intramural diverticulum was filled with barium postoperatively and a roentgenogram taken to show the extent and ramifications of the lesion. (*A*) Anteroposterior and (*B*) lateral views.

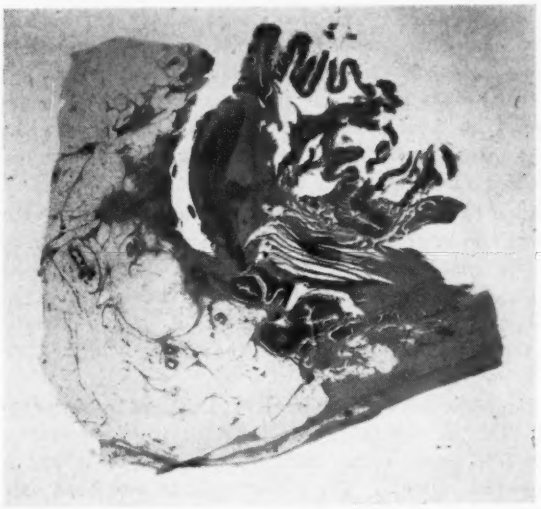


Fig. 4.—Microphotograph of histologic section illustrating luminal mucosa, an area of the intramural dissecting diverticulum, slight peridiverticulitis, and three conventional diverticula.

lations, the most orally located, had its progression through the wall arrested, was turned distally, and then was propelled isoperistaltically within the wall of the bowel. Diverticulitis set in, which accelerated the dissection. The conver-

sion of the diverticulum into a chronic sinus aggravated the condition, facilitated its extension, and led to the formation of the lateral components. When this cavity became filled with feces and/or gas, the patient developed signs of obstruction. The degree of peridiverticulitis was not pronounced so that this feature was not appreciable in the onset of the ileus which caused admission to the hospital. At the time of the operation, little feces was encountered and the intramural diverticulum was ballooned out by gas under pressure. Its cloaca was edematous, therewith causing closure and a ball-valve or tension mechanism. Had the dissection gone further, with the diverticulitis burrowing into one of the distal diverticula, spontaneous healing might have occurred. In this event, the sigmoid would have shown a double-barrel configuration, the feces and gas being propelled down the accessory canal as easily as through the main lumen.

Thus, the sequence of events included sacculation, intramural diverticulum, isoperistaltic propulsion, diverticulitis, dissecting diverticulitis, tension pneumodiverticulum, and ileus.

CASE REPORT

The patient, D. B. (H6123), a 60-year-old white man, foreman-lumberman, was admitted to the hospital because of abdominal distention, pain in the left lower quadrant, and vomiting of feceslike material. For ten days there had been no defecation. The patient came as a transfer from an adjacent community hospital where he had been treated twice with a Miller-Abbott tube and enemas. The ailment was of fifteen years' duration, the initial symptoms including tympanitis, considerable flatus, borborygmi, and vague pains in the lower abdomen. These grouped themselves into bouts during which attacks he was unable to have bowel movements or expel gas. Enemas brought relief and he recalled that these episodes occurred approximately twice yearly.

One year prior to admission he suffered a bout of the same nature, which soon became rather painful and persisted. The stools were scanty, liquid, and water clear at first but then became tarlike and ribbon-shaped. In the course of a few months he grew weak but knew of no weight loss. Shortly before admission the patient ceased to void by rectum, the abdomen became distended and hard, the pain was severe, nausea appeared, and he began to vomit material of fecal character. He was treated with the Miller-Abbott tube, which relieved him, but the obstruction reappeared, did not respond to a second intubation, and thus transfer to this institution was necessary.

Physical examination revealed a muscular, well-nourished individual. Respiratory, cardiovascular, genitourinary, and neurologic systems were normal. Laboratory tests disclosed no abnormal values. A flat plate of the abdomen showed numerous loops of small bowel and the transverse colon distended by gas with little feces visible. A barium enema could introduce the contrast substance only up to the sigmoid. A definite irregularity of the mucosal pattern was noted in the mid-sigmoid region and the roentgenologist thought he could identify diverticula.

The admission diagnosis included obstructive ileus due to pathology in the mid-sigmoid, probably a neoplasm. On the eighth day of hospitalization exploration was carried out on the patient through a left, lower rectus incision. A large mass was found at the junction of the descending colon and sigmoid. The tumor could be mobilized only after some difficulty because of dense adhesions and diffuse fixation. After delivery through the incision, the morbid portion of the gut was resected and a double-barrel Mikulicz colostomy made. Three months thereafter, the closure of this colostomy was attempted but multiple fecal fistulas had developed. Six months after the initial laparotomy, a scar containing two draining sinuses and the loop of the bowel with the primary colostomy opening were dissected out; a third fistulous tract was found. All were excised and the original colostomy closed. Recovery was rapid and the man has been well during seventeen months of follow-up.

SUMMARY

1. A form of diverticulum of the colon is described which begins as a herniation of the lumen into the wall of the bowel. This sacculation then burrows its way along the wall. The term dissecting (intramural) diverticulitis is being applied to this type.

2. The details of a case are given in which the sequence of events included sacculation, intramural diverticulum, isoperistaltic propagation, diverticulitis, dissecting diverticulitis, tension pneumodiverticulum, and ileus.

THE ANATOMICAL HAZARDS OF LINGULECTOMY

EDWARD A. BOYDEN, PH.D., MINNEAPOLIS, MINN.
(From the Department of Anatomy, University of Minnesota)

IN A recent detailed analysis of variations in the left upper lobes of fifty lungs* certain striking departures from the usual patterns were noted in the lingular segments—those portions of the upper lobe most commonly resected for bronchiectasis.

In most specimens the lingular bronchus is long and divides into the usual superior (B^4) and inferior (B^5) segmental bronchi.† In 22 per cent, however, it divides early, and atypically, into an upper, posteriorly placed bronchus and a lower, anteriorly placed bronchus. In about one-half of these (12 per cent) the upper stem is the posterior ramus B^4a, and the lower a combined B^4b and B^5; but in the remaining 10 per cent the upper stem is an *accessory posterior bronchus* (BX^2a) which is supplying the interlobar side of the anterior segment (Fig. 1). Accordingly, if the operator were to separate the lingular from the anterior segments in the usual plane (see arrow, Fig. 1), he would cut across this accessory bronchus and associated artery and compromise the blood supply to what is usually the interlobar portion of the anterior segment.

This accessory bronchus (occurring in 10 per cent of specimens) seems to represent an attempt of the lingular stem to take over that portion of the anterior segment in which the posterior ramus (B^2a) has failed to develop. In the remaining 30 per cent of specimens in which B^2a has failed to develop, the territory is taken care of by a shifting of the posterior rami of adjacent segments (either by rami B^4a or B^3b, or both). An interesting consequence of this is that whenever B^2a is absent, the posterior vein (V^3), or part of it, changes its course and passes between the lingular and anterior segments instead of between the anterior and apical-posterior segments. Therefore, in 40 per cent of specimens one should expect to find a big aberrant vein (VX^3) in the "avascular" plane between the lingular and anterior segments.

A third point of practical importance is that in 22 per cent of specimens the lingular arteries arise from both anterior and posterior (interlobar) aspects of the lobe and in another 8 per cent they arise wholly from the anterior side. In this position they are usually concealed by the branches of the superior pulmonary vein.

Fourth, the artery to the interlobar surface of the anterior segment (A^2a or AX^2a) arises in conjunction with the lingular arteries in 38 per cent of specimens. Thus, in resecting the lingular segments it is very easy to compromise the blood supply of the anterior segment.

Received for publication, Sept. 6, 1946.

*Boyden, E. A., and Hartmann, J. Francis: Am. J. Anat., November, 1946.

†For terminology, see SURGERY 18: 706, 1945.

Fifth, the inferior lingular segment drains into the inferior (instead of the superior) pulmonary vein in 10 per cent of specimens and in another 6 per cent receives tributaries from the lower lobe.

Finally, among other variations, mention may be made of the occurrence of a trifurcate (instead of the usual bifurcate) pattern of bronchi in one-fourth of the specimens. This is due to the presence of an *accessory anterior bronchus* (BX^2b) which grows in between the anterior (B^2) and apical-posterior segments (B^{1+3}) and shifts the anterior segmental bronchus to a central position.

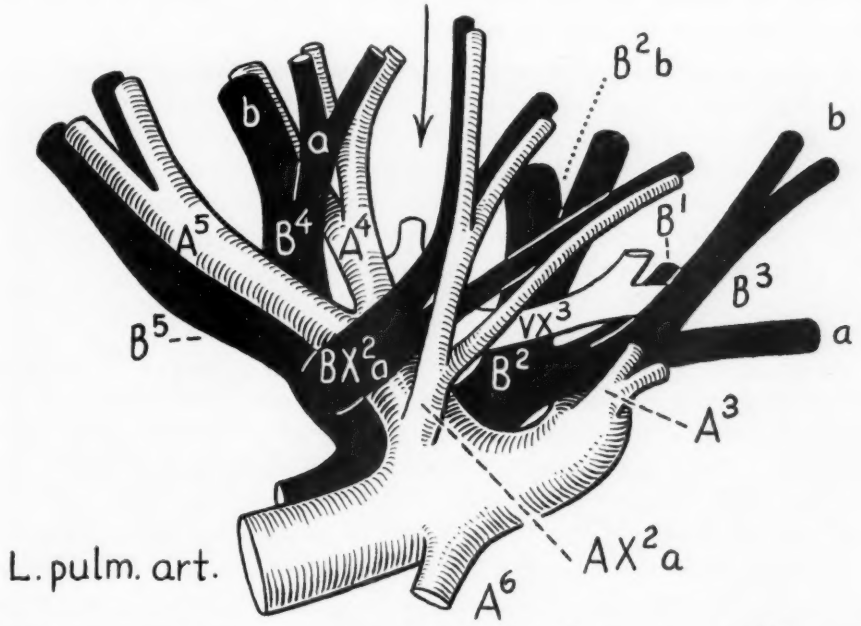


Fig. 1.—Diagram showing accessory posterior ramus (BX^2a) seen from interlobar aspect of left upper lobe. AX^2a, artery to accessory ramus; A^3, posterior subsegmental artery; A^4, superior lingular artery; A^5, inferior lingular artery; B^4a and B^4b posterior and anterior rami of superior lingular bronchus; B^5 inferior lingular bronchus; VX^3, aberrant course of posterior vein; B^2b, anterior and lateral rami of anterior segment. (The posterior ramus, B^2a, is missing and is replaced by BX^2a, an aberrant outgrowth of the lingular stem); B^1, apical bronchus. (After Boyden and Hartmann, Am. J. Anat., 1946.)

As a consequence, ramus B^2a, which in lung abscess (Brock) is the most commonly involved of the left upper lobe bronchi, becomes a direct continuation of the upper lobe bronchus and thus is most favorably placed to receive aspirated material. Perhaps it is this shift in position which has rendered this bronchus so susceptible.

These and other variations are presented in numerous colored plates in the article cited (1946) and the terminology of the left upper lobe is brought into conformity with new observations.

A METHOD OF CRANIOPLASTY USING A READY-MADE TANTALUM CRANIOPROSTHESIS

LIEUTENANT HUNTER J. MACKAY AND LIEUTENANT LAWRENCE A. RUSSELL, MEDICAL CORPS, U.S.N.R.

THE purpose of this paper is to describe a simple, easy, and quick method of repairing cranial defects from a basic, "ready-made," tantalum cranioprosthesis, to present the logic supporting the method, and to describe a technique of fabricating the basic prosthesis.

Briefly, a hemisphere of tantalum with a fixed radius is fabricated by hammering. This serves as an exemplar from which one or more cranioprostheses of any specifications may be cut and which is sterilized with the instruments for all craniotomies in anticipation of a possible need. All preliminary impressions, molds, models, or casts of cranial defects, or of the skull itself, or any intermediate preparatory craniotomies, are unnecessary and no special instruments, tools, or presses are required for shaping the metal.

LITERATURE

Adapted to the repair of cranial defects since the advent of World War II,[3] tantalum has enjoyed extensive application and many procedures designed to enhance its actual manipulation have been reported. These are either based on conforming a cranioprosthesis according to an impression of a cranial defect, made indirectly through the scalp[2, 7-9] at an intermediate craniotomy,[8, 9] or, by shaping the prosthesis from the flat, sheet tantalum at the operating table.[4, 6, 8]

We have found no reference to a ready-made method of tantalum cranioplasty. The possibility of forming a basic tantalum cranioprosthesis over a cast of the skull has been suggested very recently,[9] however, and similar attempts to use the difficultly workable vitallium have been made.[1] It is also of passing interest that the South Sea Islanders of long ago unwittingly combined the advantages of a spheric surface in a ready-made cranioprosthesis when repairing cranial defects with coconut shell,[10] although doubtless a matter of supply and not principle.

BASIC CONSIDERATIONS

Most of the calvarium is essentially little more than a composite of segments of four spheroidal surfaces centered around the four major prominences of the skull (Fig. 1). A series of measurements have demonstrated these to possess equal radii within negligible limits of difference. Experience has revealed these surfaces to constitute the only real problem in cranioprosthetics by any method as the intervening planispheric surfaces are easily duplicated, even at the operating table.

Received for publication, Jan. 19, 1946.

This paper was prepared in the Neurosurgical Section of the U. S. Naval Base Hospital —18, Guam, Marianas Islands.

The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or as reflecting the views of the Navy Department or the Naval Service at large.

The common radius of these major surfaces proved to be 2¼ inches in each instance. Admittedly, there is error in our mathematically unrefined mensuration procedures, using modeling clay impressions or conformed tantalum strips and estimating their degrees of curvature, but this is certainly no greater than the slight individual variations and minor irregularities that normally exist in the conformation and contour of the skull. An equal error, or more, must exist when a cranioprosthesis is formed from an impression obtained at intermediate craniotomy. This error must increase when the impression is made indirectly through an abnormal and deformed scalp before the underlying bony defect has been either surveyed or treated.

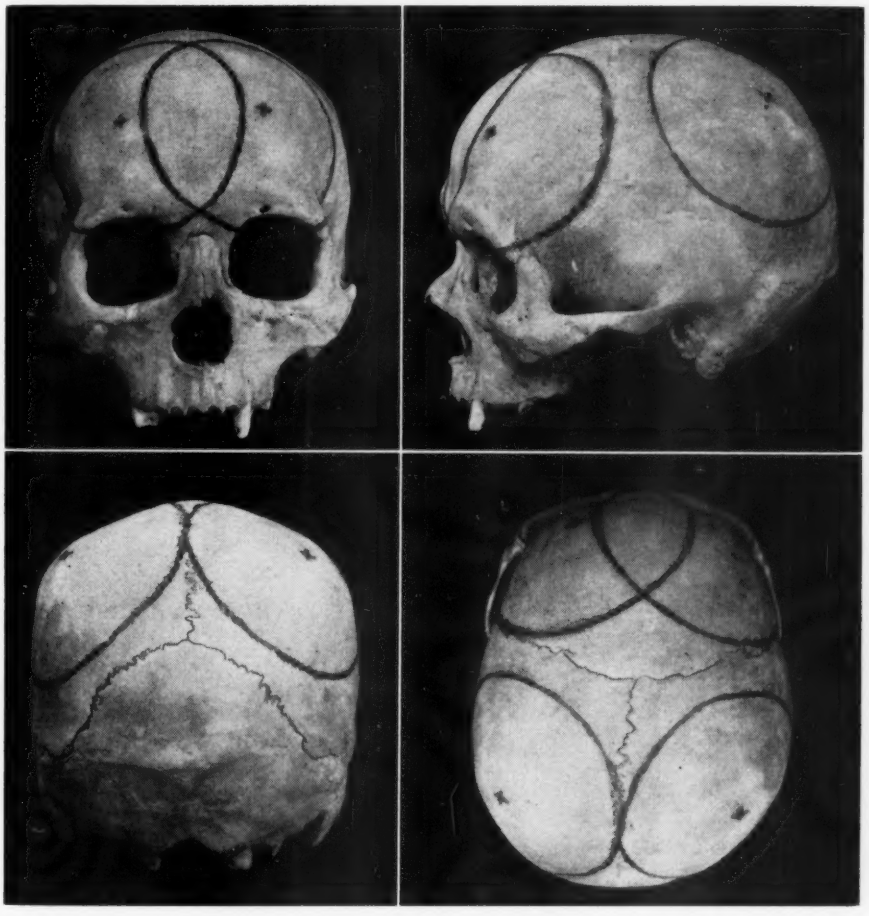


Fig. 1.—The four spheroidal segments of the calvarium, all with equal radii.

Were the skull transparent, it would not be at all difficult to visualize it as containing four spheres of equal radii, each centered on a perpendicular to the tangent of its surface through the central point of each major prominence. These points projected on a skull (Fig. 1) aid in demonstrating the fundamental geometric premise on which we have proceeded.

This method of cranioprosthetics, then, is simply that of replacing one spheroidal surface by a basically identical one of different composition, tantalum

in this case. On the premise that these surfaces always have approximately the same curvature, a basic exemplar of equal radius is employed instead of resorting to various impressions, molds or casts. To demonstrate the validity of this premise, a half-segment of a basic tantalum cranioprosthesis was placed on a skull in various positions (Fig. 2). A remarkable duplication of the natural skull conformation was evident without any alterations of the metal whatever.

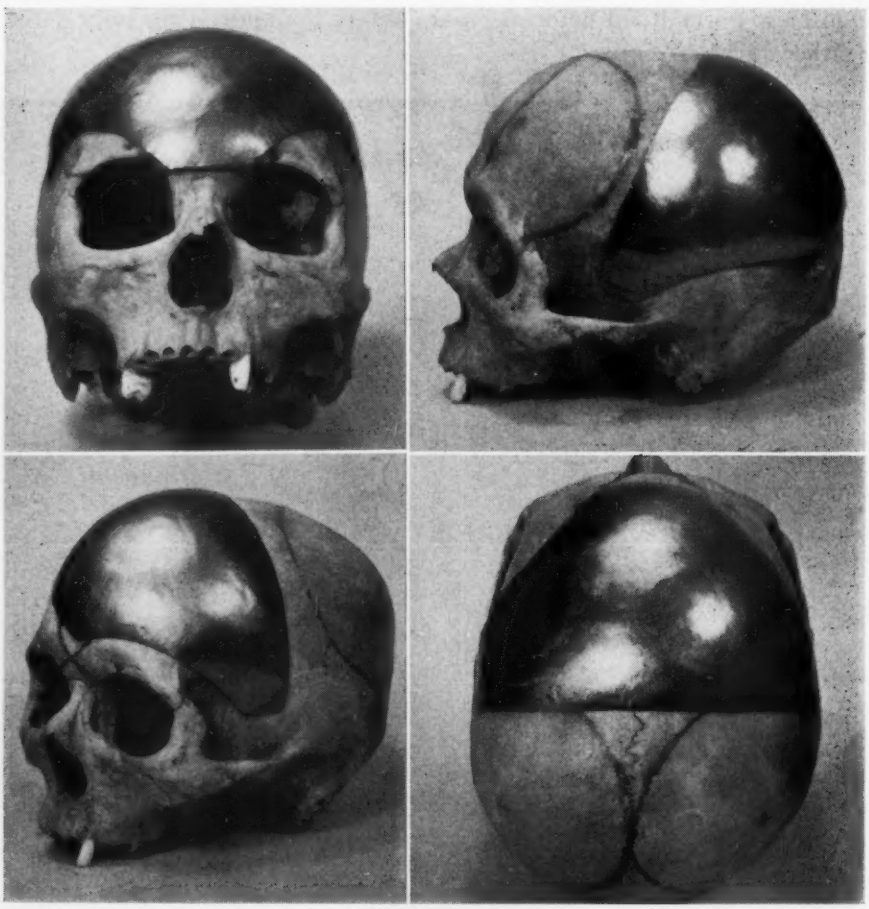


Fig. 2.—Conformity of a half-segment of a basic, tantalum, cranioprosthesis variously positioned on a skull.

The size of the cranial defect and its anatomic location need not adversely influence any intent to follow the method. Whether repairing a simple, comparatively flat temporal or parietal defect (Fig. 3, *e*, *f*, *h*), or the more complicated frontal, frontoorbital, or hemicranial varieties (Fig. 3, *a*, *b*, *c*, *d*, *g*, and *i*), the final prosthesis may be quickly fashioned from a basic, ready-made cranioprosthesis.

It must be understood that minor alterations may be necessary for an accurate duplication of a cranial defect, however, even in case of a defect in areas

of both greater and lesser curvature (Figs. 3, *g* and 9, *a*), the natural flexibility of the shaped metal in the basic cranioprosthesis conforms nicely to the surrounding contour of the skull. Any variation from the basic cranioprosthesis will be slight and may be quickly and easily obtained at the operating table.

FABRICATION OF A BASIC CRANIOPROSTHESIS

Probably the most prominent physical property of tantalum is its malleability, being comparable to the unexcelled gold in this respect. And by

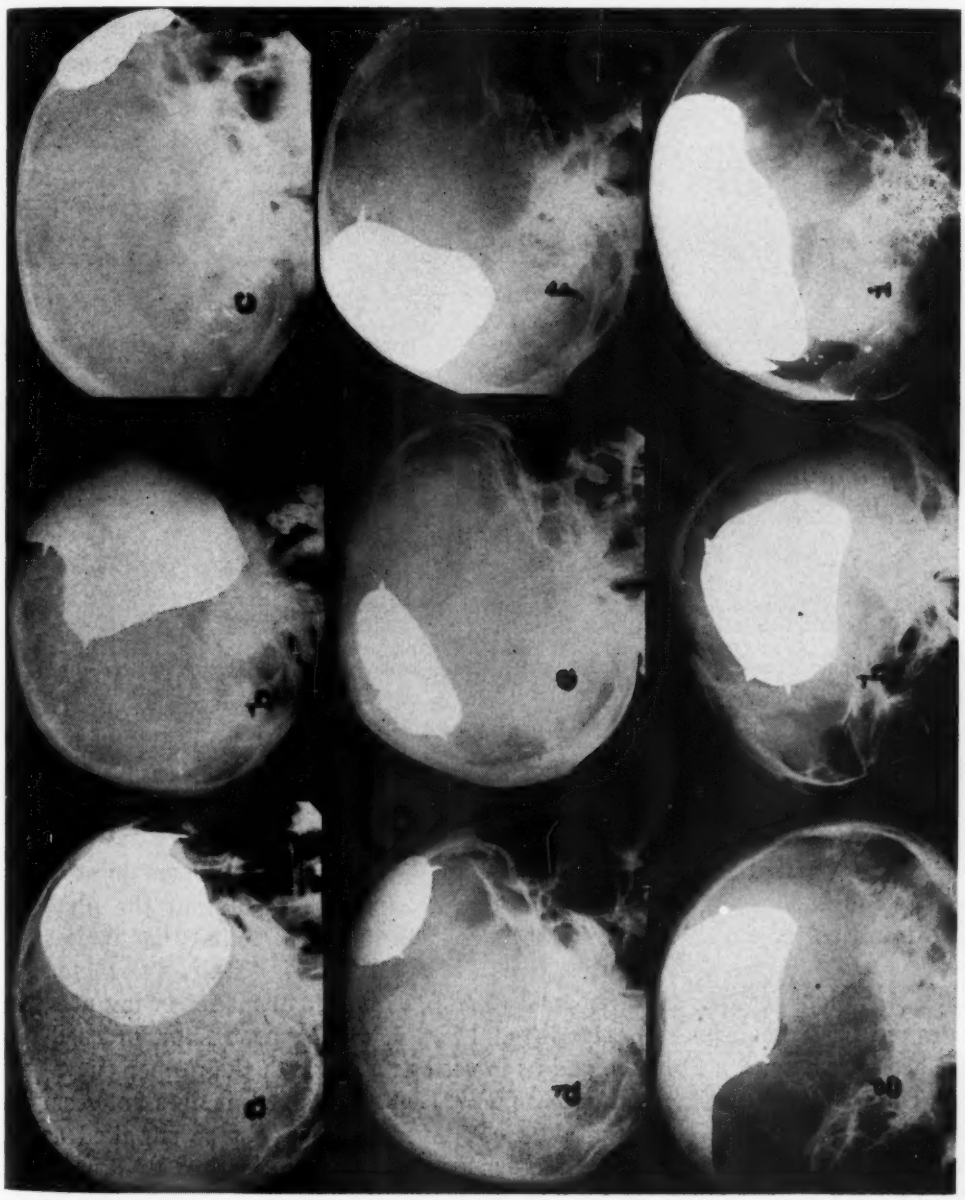


Fig. 3.—Postoperative roentgenograms: *a*, *b*, *c*, fronto-orbital prostheses (Cases 16, 7, and 17); *d*, *e*, *f*, frontal and parietal prostheses (Cases 6, 13, and 20); *g*, *h*, *i*, frontoparietal, frontotemporoparietal, and hemicranial prostheses (Cases 14, 10, and 18).

virtue of the generic derivation of the adjective itself, ". . . capable of being extended or shaped by beating with a hammer. . . ." (Webster), we have adopted this ancient artifice, the craft and skill of coppersmiths, silversmiths, and gold-beaters, in fabricating our basic tantalum cranioprostheses. The "hammering" has proved satisfactory and probably adds strength to the metal despite some slight thinning and an increase in surface area, whereas, pressing the tantalum may well create stresses and strains, as well as furrows and kinks.[10]

No special tools or equipment are necessary, although certain conveniences do facilitate the fabrication. Any hammer of the ball-peen type and an anvil of some sort suffice. Working the metal on soft lead spares it much abuse and for this reason we use a rounded, lead-filled, orthopedic mallet and a shortened, lead-filled, shell case with a cupped surface (Fig. 4).

Fig. 4.—Two basic prostheses, anvil, rabbeting chisels, lead mallet, anchoring devices, and punches.

The actual shaping of the metal is best begun by placing the center of a 6 by 6 inch, tantalum cranial plate (the 0.015 inch plate used in our cases) over the cup in the anvil (Fig. 5, *a*). The hammering is best executed by circular, tangential blows to avoid creasing the metal or breaking its surface. Work-hardening is obviated by avoiding any staccato, ditto blows on the same point of impact. The hammering should always proceed from the center of the plate outward and as the tantalum begins to take shape it will be found that it does so more readily if the corners of the plate are removed. Within five to ten minutes, the plate becomes saucer-shaped (Fig. 5, *b*) and in about thirty minutes, the desired basic hemisphere is completed (Fig. 5, *c*). A protractor, or card-board hemicircle, with a 2¼ inch radius is used as a guide to the proper curvature. To eliminate the time and actual manual labor involved, it does not seem amiss to hope that such basic tantalum cranioprostheses might be supplied as prefabricated, stock items, ready-made for use, should this method of cranioplasty find favor.

No additional treatment of the metal is necessary or advisable. Some operators prefer to perforate the prostheses with punch or drill,[4] a practice seldom followed by us. One possible refinement, that of roughening the surface of the tantalum with a hasp to elevate small burs of metal (Figs. 6, *g* and 9, *b*

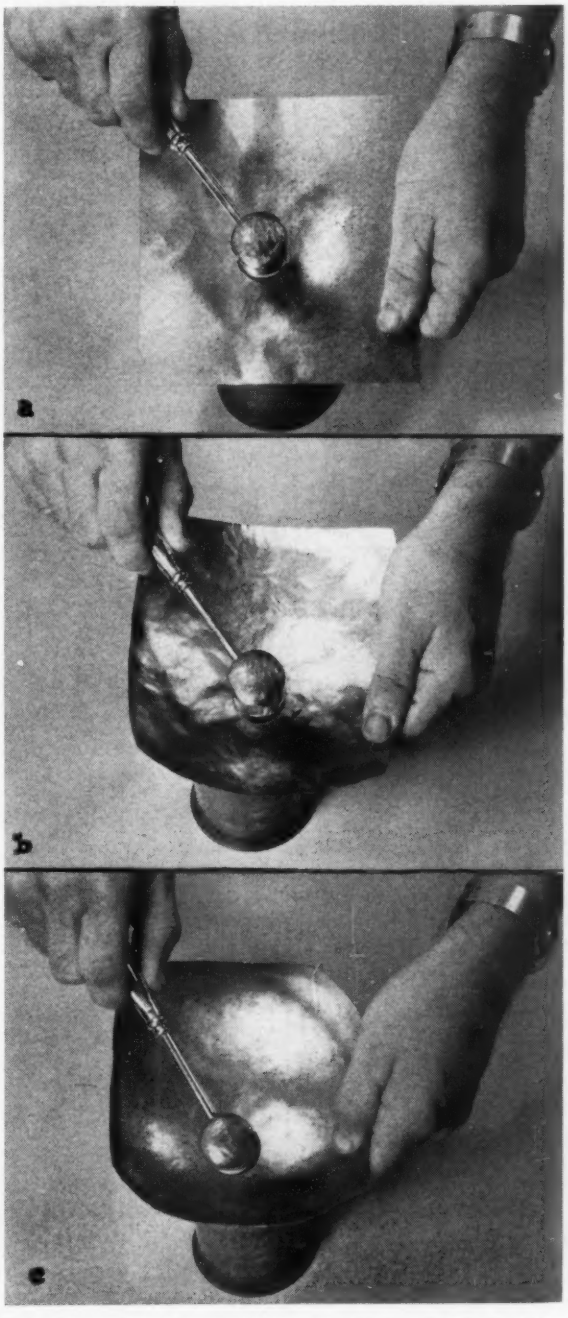


Fig. 5.—Fabrication of a basic tantalum cranioprosthesis. *a*, Hammering begun with metal over center of anvil; *b*, shaping of a prosthesis, half completed; *c*, finishing touches to a completed prosthesis.

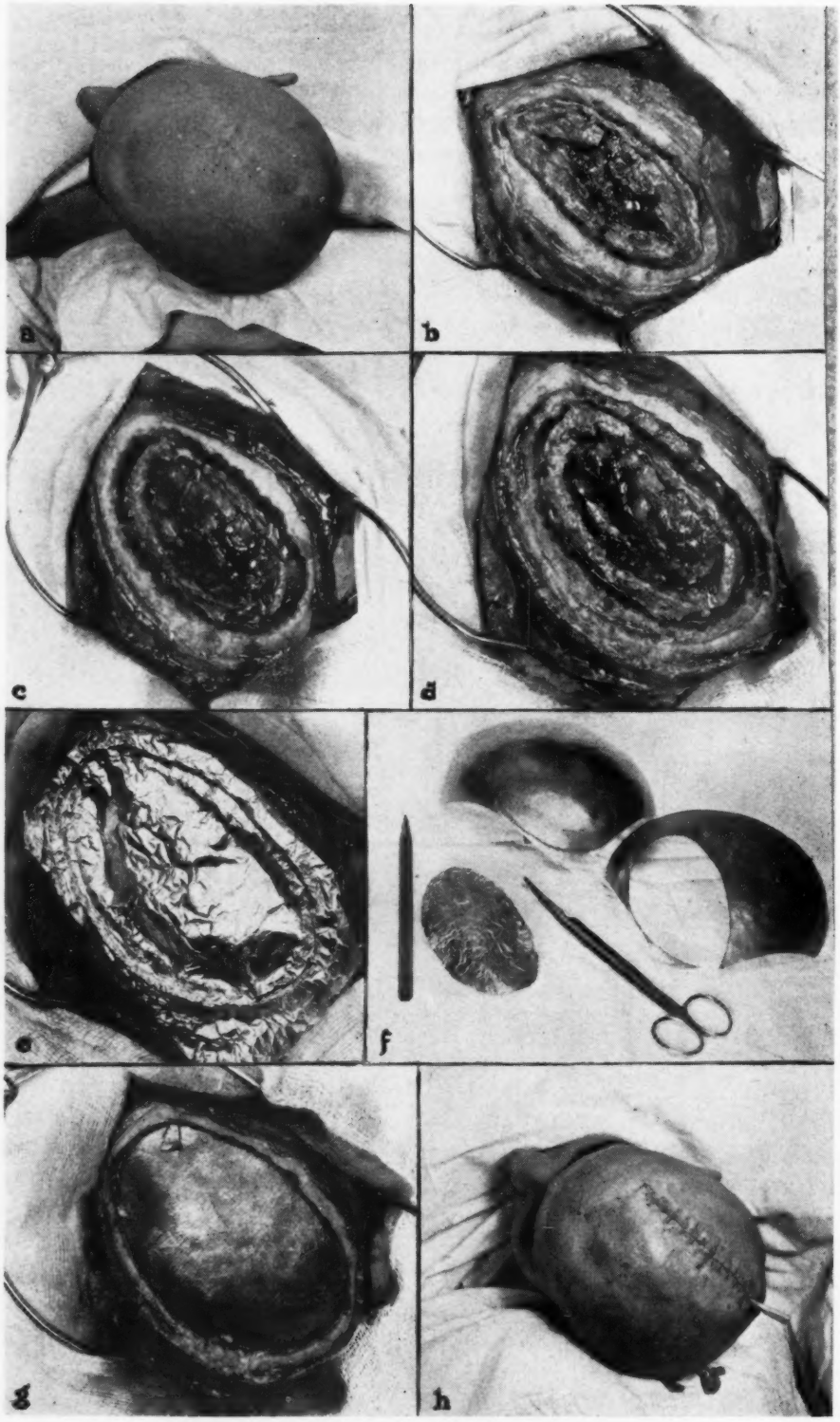


Fig. 6.—Preparation of the bone and patterning and anchoring an inlay tantalum cranioprosthesis (Case 22). *a*, Preoperative view of defect; *b*, untreated bone, dural defect, and scarred cortex; *c*, bone edge rongeured, dura and brain débrided; *d*, bone edge rabbeted and ready for the prosthesis; *e*, crimping the lead foil template along the rabbet; *f*, pencil demarcation and final prosthesis cut-out; *g*, completed inlay anchored into position with four barbed wedges of tantalum; *h*, wound sutured with figure-of-eight, nylon No. 3, over a superficial Penrose drain.

and *c*), or pitting the surface with a machinist's punch (Fig. 9, *d*), has not proved of sufficient value to warrant the time and effort expended. This idea was born of pure desperation in the hope that granulations would somehow creep across this bed in those several cases where there was insufficient scalp for closure after the ravages of bullets and débridement, and when plastic procedures were not immediately feasible.

After fabrication of a basic cranioprosthesis, there is a certain amount of metallic lead adhering to its surface from the mallet and the anvil. To remove this, each prosthesis is scrubbed in warm soapy water, with a brush and steel-wool before sterilization with the craniotomy instruments. Any adhering lead particles acquired from whatever hammering is done at the operating table can be removed by merely wiping with a wet sponge.

FABRICATION OF A FINAL CRANIOPROSTHESIS

At operation, the cranial defect is first prepared and then patterned by digitally crimping a sheet of lead foil (obtained from the waterproof wrappings of overseas cartons) along the bone edges, using care to allow for the curvature of the skull to insure a foil template of accurate dimensions (Fig. 6, *e*). This template is then placed on a ready-made cranioprosthesis in the most advantageous position and outlined with a sterile pencil (Fig. 6, *f*). This demarcated portion is now cut out with curved scissors as straight cutters tend to obliterate the curvature of the shaped metal (curved dissecting scissors suffice very well). If an onlay cranioprosthesis is contemplated, the tantalum is to be cut out a few millemeters beyond the pencil marking. If an inlay prosthesis is desired, the crimping will have been done along the shoulder of a formed rabbet (Fig. 6, *d* and *e*) and so will fit the defect exactly.

As this cut-out portion is fitted into position (Fig. 6, *g*), minor alterations may be indicated. Any unusual or accessory bends or angles, such as in the frontotemporal-orbital areas (Fig. 9, *c* and *d*), can be quickly fashioned with the same mallet and anvil that fabricated the basic cranioprosthesis and which are routinely sterilized with the craniotomy instruments also. Crinkling of the margins does not occur so that notching, folding, or serrating the edges of the tantalum is unnecessary to produce an exact fit. Once the bony defect is prepared, it requires but five to ten minutes to fashion even a complicated cranioprosthesis.

PREPARATION OF THE BONY DEFECT

The preparation of the bone for insertion of a tantalum cranioprosthesis necessarily differs with the varying situations presented. An extensive, shattering, or excavating type of skull fracture (Fig. 3, *g* and *i*) is not uncommon in combat head wounds and permits of very little bony architecturing due to the insecure, oft-subgrondated bone fragments bounding the actual cranial defect. In such cases, the tantalum is best fitted as an onlay type of prosthesis (Fig. 9, *b* and *c*) which overlaps the bone edges by a few millimeters.

The average case is less of a problem and in these an inlay type of prosthesis (Figs. 6, *g* and 9, *d*) is preferable, especially when the cranial defect is located

where the scalp is naturally thin, when there is insufficient scalp for closure, or when in a prominent position. This type of cranioprosthesis has also proved to be particularly advantageous in those cases where a cortical scar has been resected, a fungus cerebri has existed, or a cerebrospinal fluid fistula is present.

In all cases, the edges of the bony defect are rongeured away until viable bone is encountered, irrespective of whether the wound is fresh or some weeks or months old (Fig. 6, *a*, *b*, and *c*). When using an onlay type of cranioprosthesis, no additional treatment of the bone is either necessary or advisable.

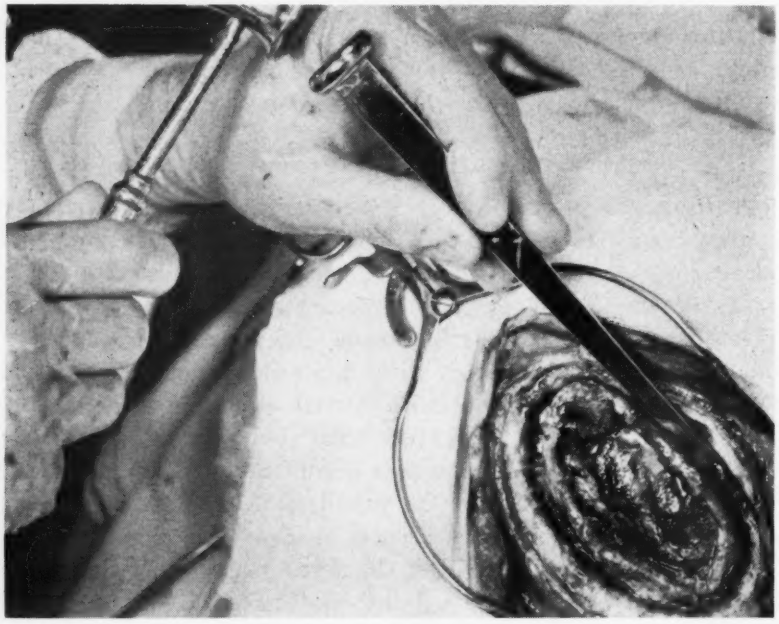


Fig. 7.—A method of rabbeting the bone edge using a right-angle rabbeting chisel.

An inlay cranioprosthesis is made possible by the tablature of the skull. The freshly rongeured bone edge is rabbeted down through the outer table and diploë to the harder inner (vitreous) table (Fig. 7). This forms a rabbet, or rout, with an approximate one-fourth inch shoulder, for the support of the prosthesis (Fig. 6, *d*). This procedure may be done with an ordinary flat bone chisel and mallet, or, a Stout No. 3 dental chisel.[9] The attendant jarring is considerable and objectionable, however, to diminish this, we made a one-fourth inch rabbeting chisel from a common one-half inch, flat, carpenter's chisel (Figs. 4 and 8). This markedly reduced the trauma and conserved time, since the rabbet is formed in but one excursion of the chisel around the edge of the bony defect. This first instrument was later improved to obtain a better cutting edge and gain a little streamlining, culminating in the tool steel rabbeting chisel now in use (Fig. 8).

ANCHORING A COMPLETED CRANIOPROSTHESIS

Although high in the electrochemical series, use of dissimilar metals is to be avoided, and only tantalum fittings should anchor a tantalum cranio-

prosthesis. Vitallium screws have, however, apparently been successfully used with tantalum[7] for this purpose. Before securing a prosthesis, we even remove superficially placed silver hemostatic clips when present from an operation performed elsewhere. Tantalum hemostatic clips are not objectionable, of course.

The only other admonition is that cranioprostheses which are insecurely fixed to the bone interfere with the formation of the characteristic membranous envelope around the tantalum. Also, even slight mobility disturbs healing and may actually erode the overlying soft tissues.

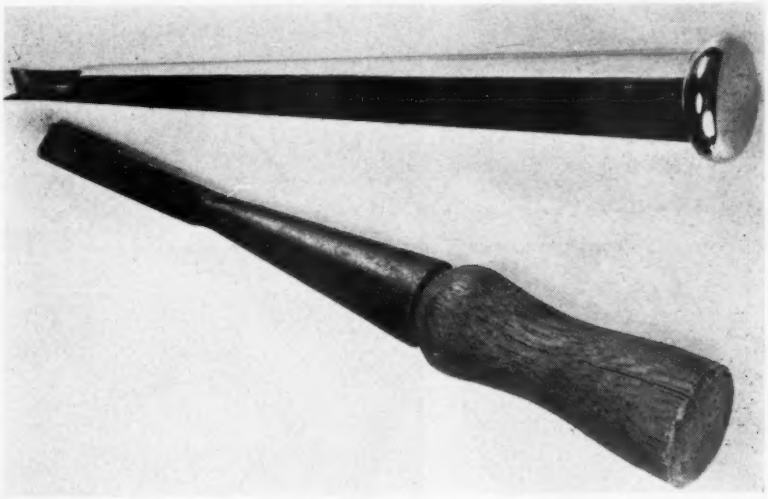


Fig. 8.—Rabbeting chisels, the new and the old.

As noted earlier, an onlay cranioprosthesis frequently constitutes somewhat of a problem in bone preparation due to the insecurity of the fragments, and the same problem obtains regarding its fixation. Tantalum screws are probably the ideal fittings, and, while they have not been available to us, they can be satisfactorily homemade.[4] There are several alternate methods of fixation, such as ordinary suture materials, tantalum wire, tantalum ribbons (cut from scrap and used like wire) and tantalum cotter pin, or, paper fastener-shaped devices (also fashioned from scrap). Tantalum wire was used in two cases by one of us (H. J. M.), with some difficulty in binding the prosthesis down tightly to the bone. The ribbon, used because wire was not available, does not have this objection but it does leave an undesirable elevation in the scalp (Figs. 3, *g* and *i* and 9, *a* and *c*). The cotter pins, proved satisfactory in the one instance they were used (Figs. 3, *c* and 9, *b*), are inserted from the dural aspect of the bone, points upward, through matched holes drilled in the bone and the prosthesis.

An inlay prosthesis may be cut to size and shape so very accurately that it need be sprung slightly to fit into its bed.[9, 10] We have elected to secure the prostheses in our cases with glazierlike wedges, points, or triangles, lest they become dislodged. This is not an original practice,[2, 4, 9, 10] but a useful refinement is to barb, or feather, the entering margins of these wedges toward their base, offsetting alternate barbs slightly, like saw blade teeth (Fig. 6, *g*). Once

in position they are very difficult to remove. Again, it does not seem amiss to suggest that these devices might also well be supplied as stock items ready for use.

The driving-in of the wedges without buckling them or chipping the bone is facilitated by first punching a small flattened opening into the outer table, or diploë. A short, flat punch devised from a screw driver serves the purpose; a similar punch made from a discarded dental chisel serves equally well but does

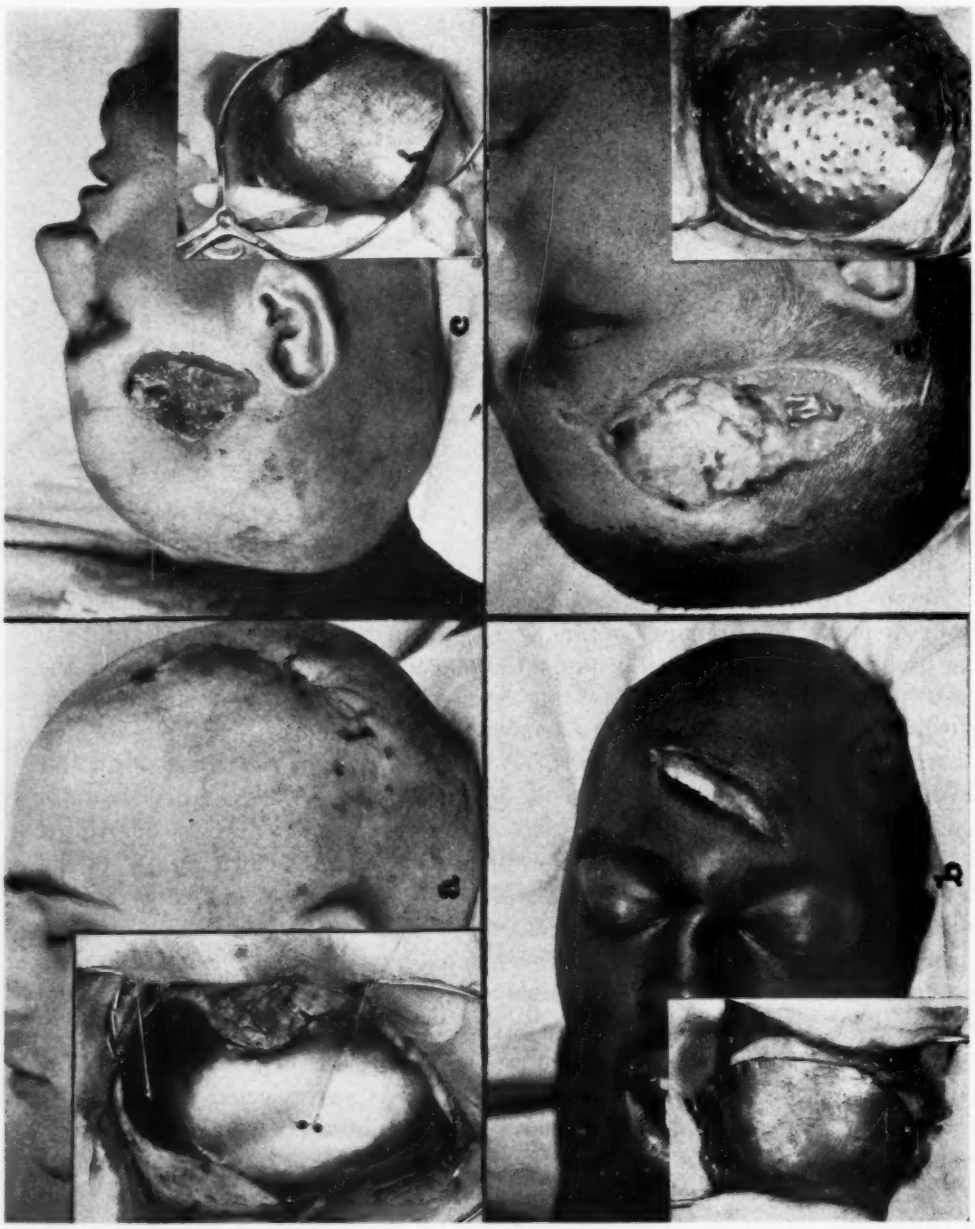


Fig. 9.—Various types of cranioprostheses anchored in place. *a*, Combination onlay-inlay prosthesis (see Fig. 3, *g*); *b*, onlay prosthesis, rough surface (see Fig. 3, *c*); *c*, combination onlay-inlay prosthesis (see Fig. 3, *a*); *d*, inlay prosthesis, nut grater surface (see Fig. 10, *b* and *b'*).

not tolerate much punishment (Fig. 4). With this initial precaution, it has not been necessary to fashion the wedges from a heavier gauge tantalum.[10]

An inlay prosthesis may also be secured with tantalum wire[4, 9] which passes through matched holes drilled in the metal and one, or both, tables of the skull. Occasionally, it is necessary to resort to a combination onlay-inlay cranioprosthesis with appropriate anchoring devices (Fig. 9, *a* and *c*). Temporal prostheses are often difficult of fixation due to the extreme thinness of the bone. Cutting notches and offsets in the edges of the metal and riding these on the bone edge, in clothespin fashion, serves satisfactorily.

Other but less practical anchorings have been tried and abandoned. The most promising of these was that of retaining several pointed flukes on the edges of a completed prosthesis and attempting to fit these into corresponding slits punched into the outer table or diploë. Tantalum is far too ductile a metal, however, to allow much manipulation of this kind. Occasionally, one or two flukes may be retained and fitted into appropriate notches in the outer table to obviate any displacement when the wedges are not sufficient in themselves.

Irrespective of the type of cranioprosthesis employed, it is covered with the periosteum, if there is any remaining, before the scalp is sutured. Any preference of scalp suture is satisfactory. We have utilized but a single layer of interrupted, through-and-through, figure-of-eight, cotton or nylon sutures in the majority of our cases. These are widely spaced to maintain the maximum blood supply. Closure is rapid and prompt healing follows. When suturing below the hairline, however, a single row of inverted, interrupted cotton sutures in the galea leaves a less obvious scar. A dependent Penrose drain may be indicated for twenty-four to forty-eight hours, depending on the amount of oozing, and not infrequently we found it imperative also to place a hemostatic gauze pack in the absence of either an electrocoagulator, hemostatic clips, or fibrin foam.

The usual head dressing consists of two elastic bandages tightly applied over an abundance of well-fluffed, gauze sponges. Unless a drain must be removed, this initial dressing is not molested for the first five days. Fluid collections under the scalp have not been a problem and aspiration was necessary in but three cases, on one occasion in two cases, and on three occasions in the other case.

MATERIAL

This method of employing ready-made, tantalum cranioprostheses for the repair of cranial defects has been used by us in a series of twenty-five cases since September, 1943, all involving service personnel. The majority have been operated upon since May, 1945, however, pursuant to the bloody Iwo Jima and Okinawa Campaigns.

Of the total, seventeen were compound, comminuted, depressed fractures sustained in combat, seven were injuries of a similar nature but received in some other manner, and, one was a defect remaining after removal of an osteoma and adsorption of a rib graft performed elsewhere. All but four cases had associated penetrating wounds or lacerations of the brain and nineteen had dural defects

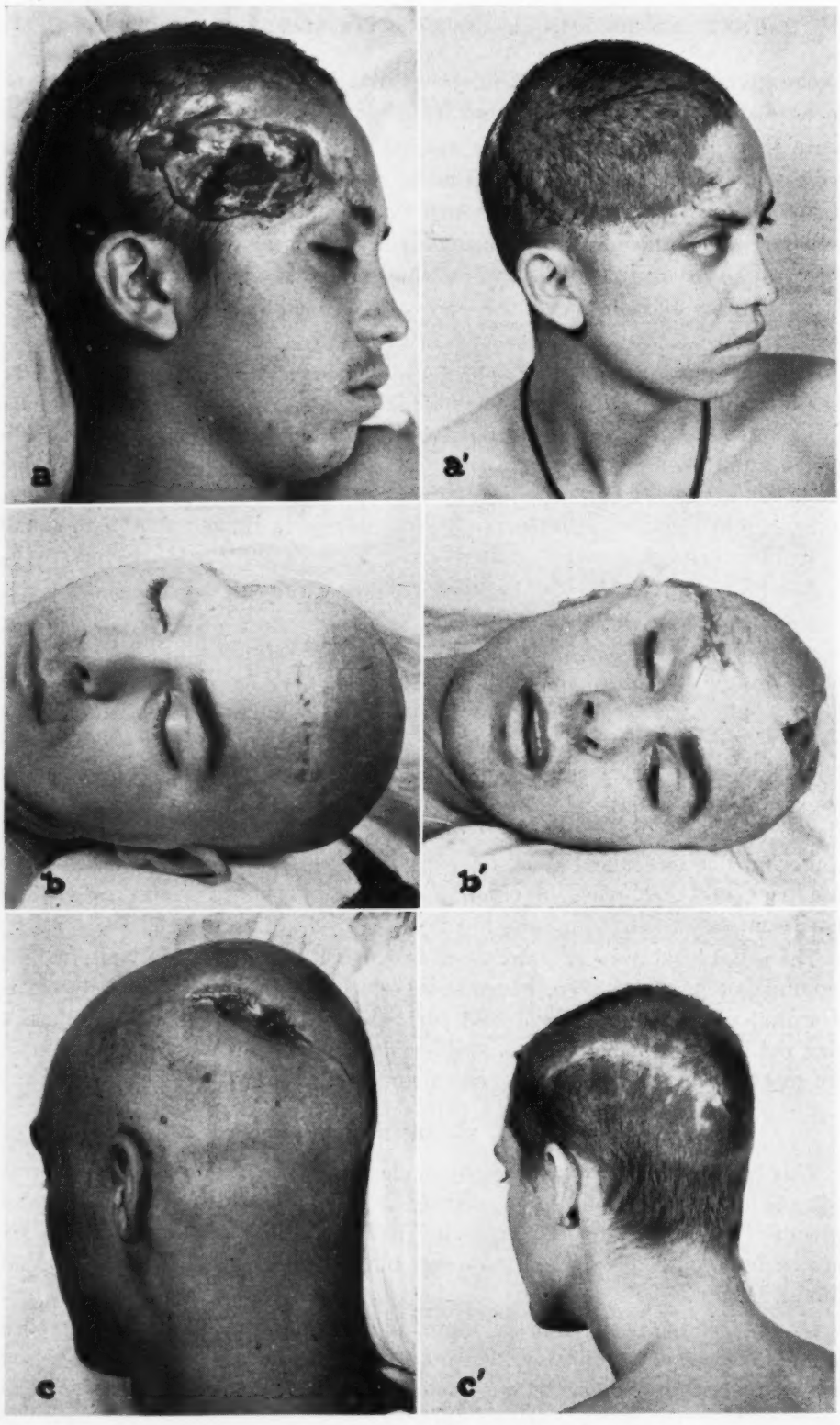


Fig. 10.—Preoperative and postoperative photographs demonstrating wounds, defects, and closures. *a* and *a'*, Fungus cerebri and cerebrospinal fluid fistula; pedicle scalp flap placed over prosthesis (Case 7, see Fig. 3, *b*). *b* and *b'*, Operative views of case similar to Case 7 (Case 24, see Fig. 9, *d*). *c* and *c'*, Posterior parietal defect (Case 9).

underlying the tantalum. There were three fatalities in the series, not in any way attributable to either the cranioplasty or the presence of the tantalum cranioprosthesis.

The anatomic distribution included every region of the calvarium with two frontal, two frontoorbital, four frontotemporal, two temporal, two vertex, seven parietal, one occipital, and five hemicranial defects.

In nine of the cases, brain, skull, and scalp alike all constituted one large open wound and in five other cases we were confronted with thick, extensively scarred, and distorted scalp overlying tremendously misshapen, comminuted, and depressed bony defects. Of the total of fourteen cases so complicated, in eight the scalp and periosteum were so severely lacerated, contused, and/or debrided as almost to preclude primary closure, with a total absence of these tissues in the region of the defect in one-half of them. Pedicle scalp flaps were necessary in eight of the fourteen cases, the presence of other scalp lacerations often making this difficult and even dubious on occasion. In five of these, and one additional case, there was a loss of temporal muscle which was particularly deforming (Figs. 9, *c* and *d* and 10, *a*, *a'*, *b*, and *b'*).

Case reports have been intentionally omitted from this discussion in deference to a second paper now under preparation, on the entire series of cases. We have used some of the photographs and roentgenograms of a few of these to illustrate the points we wish to emphasize.

RESULTS

The results were considered to be technically and esthetically satisfactory in all twenty-five cases, of which there were five onlay, eighteen inlay, and two combination onlay-inlay types of cranioprostheses. At this writing, we are satisfied with the method but not to the exclusion of anticipating improvements or better methods. Until indications appear to the contrary, we shall continue to employ the techniques described. In general, this group of cases presented problems not ordinarily encountered in cranioplasty. Some of the combat wounds aroused despair for life itself, without regard to esthetics or the procedures to gain it best.

The greatest single obstacle to complete cosmetic success was the distressing loss of soft tissue and its blood supply by explosives, missiles, scalpel, or other means. We have not been fortunate in the use of pedicle scalp flaps in these particular cases, a procedure that is deforming in itself, which suggests the use of grafts from another part of the body. A successful case of this kind has been reported just recently.[5] While we have failed to cover completely an underlying tantalum cranioprosthesis in several instances, the naked area has at least been reduced to a size consistent with grafting, in a rear-area hospital. The patients have enjoyed the distinct advantages of the cranial repair meanwhile (Fig. 10, *a*, *a'*, *b*, and *b'*). In those patients sustaining loss of temporal muscle, it seems advisable to be content with an initial accurate cranioprosthesis. Any residual deficit that is detrimental or disturbing to the patient can await later correcting, plastic procedures.

It is quite likely that methyl methacrylate will supplant tantalum as a cranioplastic material. Definite possibilities of greater ease in correcting tissue losses are suggested by the lighter weight of the substance and the fact that it welds readily. We are attempting to adapt plexiglas (methyl methacrylate) to this method of cranioprosthetics described for tantalum, at the present time.

CONCLUSIONS

1. The logic, fabrication, and method of using a hemispheric, ready-made tantalum cranioprosthesis is described.

2. The technique of patterning onlay and inlay types of cranioprostheses is detailed and various anchoring devices are discussed.

3. A new rabbeting chisel is described.

4. The major virtues of the method are:

   (a) A ready-made tantalum cranioprosthesis is available at all cranial operations.

   (b) All impression materials and processes, and any intermediate preparatory craniotomies, are eliminated.

   (c) Anatomically symmetrical and accurate cranioprostheses are provided without delay or difficulty.

   (d) It is readily available to military surgeons, in general, and appears applicable to the traumatic and industrial neurosurgical counterparts in civil practice, as well as the customary cranioplastic demands.

5. A total of twenty-five cranial defects have been repaired by this method, with technically satisfactory and esthetically acceptable results in all.

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Recent Advances in Surgery

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NASAL DEFORMITIES AND THEIR REPAIR

KENNETH L. PICKRELL, M.D., DURHAM, N. C.

(From the Division of Plastic and Maxillo-Facial Surgery, The Duke University School of Medicine and Duke Hospital)

THE esthetic importance of the nose is great because of its prominence on the face. Since the sequelae of injury or disease are so disfiguring, and congenital or developmental abnormalities so frequent, the plastic surgeon is repeatedly called upon to reconstruct the nose or to improve the appearance of the part that remains. To many physicians, however, the nose may be a rather uninteresting part of the body, unless there is some nasal obstruction or impairment of breathing; but to the individual, an external deformity of the nose may be the primary object of his concern, though no obstruction exists; and this, regardless of whether the deformity is congenital or the sequelae of injury or disease. In the business or social world, the person with an unsightly nasal abnormality may be seriously handicapped and consequently develop somatic and psychic disturbances attributable to its presence. In many instances these visible and conspicuous nonconformities are more harassing than congenital or acquired defects in other parts of the body. It is true that many individuals quite readily compensate for physical or physiologic impairments, but in the case of facial disfigurement, there is no mechanism that will shield a defensive individual from a continued attack upon his self-esteem. The person who is unhappy because of an unsightly nose or protruding ears will find his inner security assailed each time he looks into a mirror. These unfortunates, children or adults, should, therefore, be given an opportunity to have this barrier removed, even though life is not endangered by the affliction, and they should not be encouraged to endure the misery and abuse to which they are predestined, for no one knows the indelible mental effects produced on the afflicted, and, at least in some instances, ridicule and contempt are a direct sequence of the deformity. The need for reconstructive plastic surgery for the correction of the condition and the elimination of the handicap and the possible mental sequelae is, therefore, evident. It should not be construed, however, that every individual with a nasal abnormality should be operated upon, for there is no proportional relationship between the size or severity of the physical defect and the reaction to it. Individuals with only slight or seemingly minor facial abnormalities frequently suffer more mental distress than those whose defects are pronounced. This mental distress, which stems not from physical factors but from psychologic ones, is as real as actual physical pain and demands tolerant and understanding consideration.

Psychiatric Diagnosis.—The plastic surgeon must distinguish between the patient whose anxiety is based upon factors other than the presenting complaint and the patient suffering from a situational reaction. If a surgeon, consulted by a patient whose psychologic state may be a reflection of the deformity, is uncertain as to the nature of the reaction or anxiety, he should have no more hesitation in requesting an interview with a psychiatrist than in asking for a medical or ophthalmologic consultation, or a roentgen examination. The psychiatrist will be able to help differentiate those patients whose reaction is related to the disfigurement and in whom a repair or improvement of the abnormality will be helpful from those with a psychiatric condition in whom repair will result only in the production of another symptom for the expression of emotional difficulties. The psychologic result of the operation in these two types of cases will be entirely different. In one instance, a helpful service will have been performed; in the other, a great wrong may have been committed. In this respect, the remarks of Blair and Brown[1] are pertinent: "As a general working rule, the more pronounced the deformity or loss, the more likely is a reasonably good result to be acceptable; but, conversely, it is well to be cautious about embarking upon the correction of slight defects. A patient's inability to state accurately and succinctly the particular thing that displeases him should excite grave self-doubt in the surgeon's own ability to satisfy. The same uncertainty should also excite the suspicion that the accused nose might not be the real fault." In this same thought Gillies[2] remarked, "The size of the hump of a nose bears little relation to the misery of the patient and to the wisdom of advising its removal. . . . Even in ordinary life a nasal defect may produce such an inferiority complex as genuinely to hinder the patient's happiness and pleasure. There is a well-known class, however, which has a nasal complex not relieved by operation, however successful, and such patients are to be avoided. But the differential diagnosis between the genuine and the false is one of considerable difficulty. The help of the psychologist is of great value when there is any doubt."

ANATOMIC ASPECTS OF NASAL DEFORMITIES

Bone-Cartilage Framework.—The two *nasal bones* articulate with each other in tent fashion to form the bridge of the nose anteriorly, and with the nasal process of the maxilla laterally. Above they are narrow and strong and supported by the bony septum. Below they become thinner and wider, and this relative weakness, as well as their exposed position, accounts for the prevalence of fractures in this location (Fig. 1).

The *septal cartilage* gives structural support and contour to the lower half of the bridge of the nose and forms the greater part of the median partition. Anteriorly it becomes continuous with the upper lateral cartilages. The septal cartilage is involved in almost every nasal disfigurement. Being a flexible body, it yields easily to pressure and may be dislocated from any or all of its attachments. If it is dislodged or bent, or for any reason it fails to exercise its function of support, the surrounding structures then also become a part of

the displacement. In the developmental stage, extending through puberty, the septal cartilage, through vertical upward pressure by the vomer below it, raises the dorsum of the nose (Fig. 1). This explains the failure of the forward extension of the nose in disease or injury to the vomer occurring before puberty. Spurs on the septum may have to be removed prior to rhinoplasty since the narrowed nasal arch may impinge upon them and cause obstruction. Associated with a long nose is an overhanging septum, and for its correction a wedge of the septum and mucous membrane is removed (Fig. 2). Should this deformity be associated with a protruding upper lip, it can readily be corrected by removing the nasal spine and readjusting the nasolabial angle after the method of Aufricht.[3, 16]

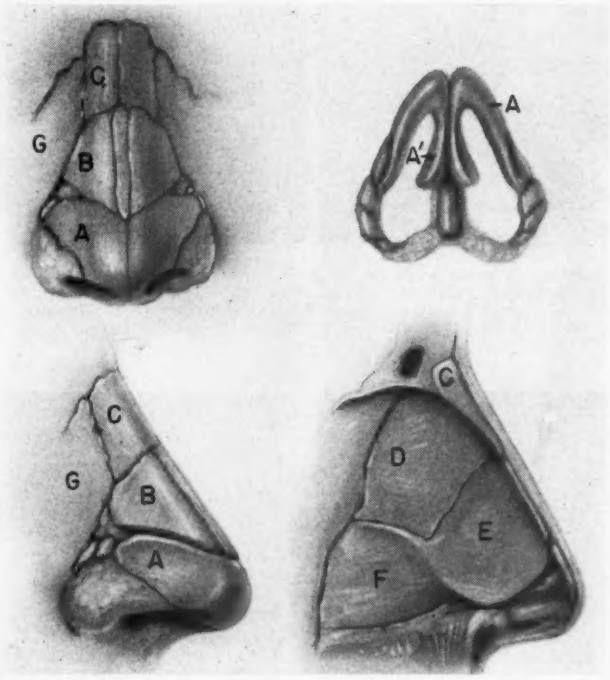

Fig. 1.—Bone and cartilaginous framework of the nose. The lower part of the nasal framework is cartilaginous, the upper part consists of bone. The nasal bony arch consists not only of the nasal bones (*C*) but also the nasal process of the superior maxilla (*G*). The lower lateral cartilage, the alar cartilage, is horseshoe shaped, consisting of a lateral crus (*A*) which aids in the formation of the ala and a median crus (*A'*) which, with the medial crus of the opposite side, supplies the structural support for the columella. The cartilaginous septum (*E*) forms the greater part of the median partition. Anteriorly the septal cartilage becomes continuous with the upper lateral cartilage (*B*), the triangular cartilages, which diverge from it in a winglike manner. The osseous septum comprises the perpendicular plate of the ethmoid (*D*), the vomer (*F*), and the frontal spine of the nasal bone.

The anterior extremity of the *vomer* abuts on the incisive crest of the maxillae and is of much surgical importance, because it is here that the lower segment of the septal cartilage which supports the tip of the nose is inserted. In submucous operations in which the thickened vomer is widely resected, and especially when the adjacent nasal spine has been sacrificed, there is likelihood of a sinking of the dorsum and a consequent lowering of the tip of the nose (Fig. 3).

Fig. 2.—A long hump nose with an associated overhanging septum is corrected by first removing the hump to lower the nasal bridge line, followed by the removal of a wedge from the anterior border of the septum together with the redundant mucous membrane, thereby elevating the tip and reducing the entire size of the nasal pyramid.

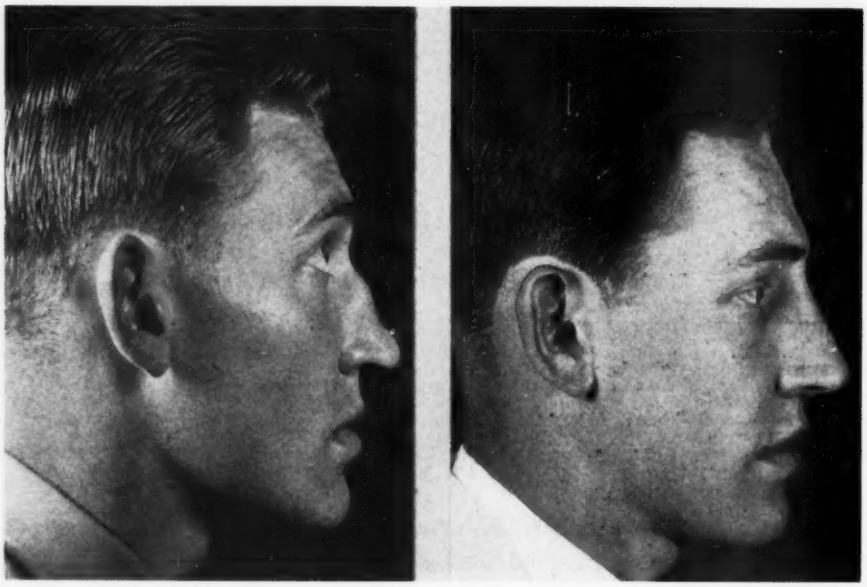

Fig. 3.—In submucous operations in which the septum is extensively resected, the thickened vomer removed, or the anterior nasal spine sacrificed, the nasal bridge line may become concave, producing a "false" hump. With the consequent lowering of the tip of the nose the columella may retract. The deformity may be corrected by insertion of an L-shaped piece of sculptured cartilage, fresh or preserved.

The *upper lateral cartilages,* the triangular cartilages, are two flat plates situated immediately below the free border of the nasal bones, spreading downward and outward from the septum with which they are directly continuous (Fig. 1). They form the approximate middle third of the nose and are extremely important elements in the maintenance of normal contour in this location. These upper lateral cartilages form the body of the nose and, with a hump, flare anteriorly (Fig. 4). With a broad bridge, they are usually widened and flat; with saddling or a depressed bridge, they are sunken and deviated (Fig. 5). Associated with an old harelip, they may be flattened and depressed on the affected side.

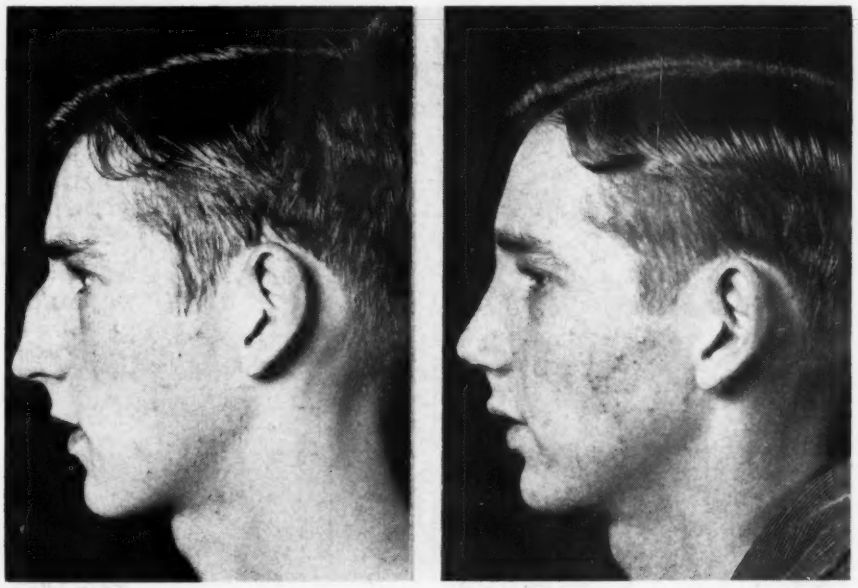

Fig. 4.—Elevation of the profile angle with essentially normal position of the tip of the nose. The deformity is corrected by removing the hump to lower the profile angle, narrowing the nasal bridge, and excising the medial margins of the upper lateral cartilages which flare anteriorly.

The *lower lateral cartilages,* the alar cartilages, encircle the nostrils and assist in maintaining their patency. Each cartilage consists of a medial and a lateral crus (Fig. 1). The two medial crura approximate each other in the median plane, and, together with their investing soft tissues, form the lower part of the nasal septum, which, owing to its free mobility, is referred to as the *movable septum.* Above, the medial crura are united to the septal cartilage; posteriorly, they end in free out-turned borders; anteriorly, they bend to form angles with the lateral crura. The approximation of the two angles then forms the tip of the nose. Sheehan[4] has stated that of all the elements of the nasal framework, the one requiring the most delicate handling is the lateral extension of the alar cartilages. The configuration of the nostrils is directly dependent upon the size, position, and contour of these cartilages.

Columella.—The character of the columella, be it long, short, narrow, or wide, will affect the shape of the nostrils. Often an oblique columella will be

straight when more of the lower lateral cartilage is removed from either one side or the other. A retracted columella may be corrected in some instances by elevation of the tip of the nose (Fig. 6). Other cases require the introduction of a supporting strut through a small separate incision (Fig. 3). A hanging columella may be corrected by removal of a portion of skin from both

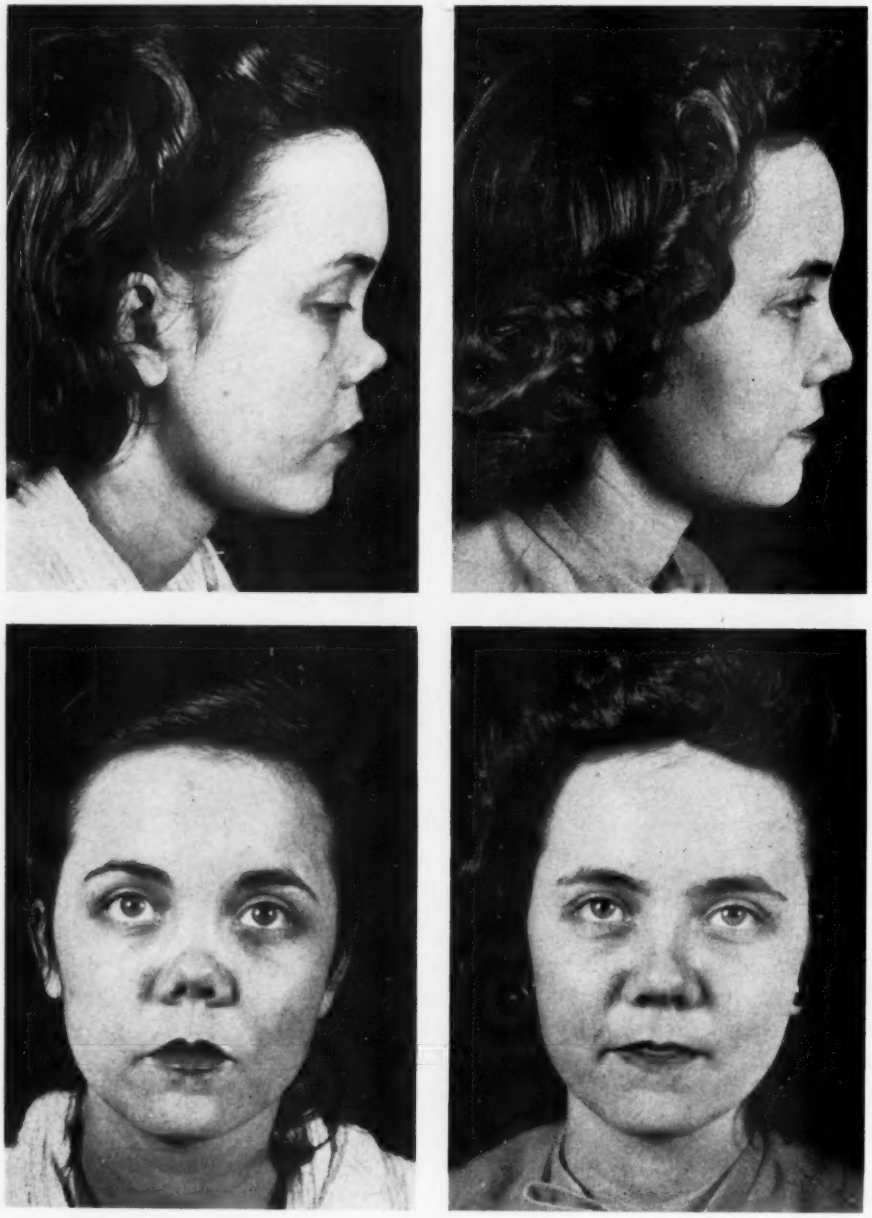

Fig. 5.—Saddle nose deformity possibly resulting from a childhood injury. In the developmental stage, extending through puberty, the septal cartilage, through vertical upward pressure by the vomer below it, raises the dorsum of the nose. This explains the failure of the forward extension of the nose in disease or injury to the vomer, occurring before puberty. This patient is unable to wear glasses because of the low nasal bridge line. Deformity was corrected in a single operation by inserting an L-shaped piece of sculptured preserved cartilage.

sides, or the utilization of the Aufricht[3] procedure to correct the nasolabial angle (Fig. 2). Occasionally surgery is required on the columella itself, such as a Z flap at the base or tip for the correction of an abnormally oblique one, or a V or Y incision at the base or tip for one especially short.

Arteries and Veins.—The arterial supply to the nose is derived from the internal and external maxillary (branches of the external carotid) and from the ophthalmic, a branch of the internal carotid. These arteries terminate in capillary plexuses which supply the nasal mucosa, glands, and skin. The *veins* form a close cavernous network immediately beneath the mucous membrane. They anastomose freely and terminate in the anterior facial and ophthalmic veins.

Fig. 6.—A small hump associated with a retracted columella may be corrected by lowering the profile angle and elevating the tip of the nose. Greater care and caution must be exercised in correcting deformities of lesser degree than in those patients whose abnormalities are pronounced.

Nerves.—The *sensory nerve supply* of the external nose is derived from: (1) the infratrochlear, supplying the skin of the root, (2) the nasociliary branches of the ophthalmic, supplying the alae and tip, and (3) the infraorbital branch of the superior maxillary, supplying the sides. The only *motor nerve* to the nose is a branch of the facial which is distributed to the alar muscles.

Muscles.—The *muscles* of the nose are vestigial. Immobilization following reduction of nasal fractures thus offers little difficulty, because there is no muscular pull that would tend to displace the fragments. The principal muscles of the external nose are the compressors and dilators of the nostrils and the depressors and elevators of the alae nasi.

PREOPERATIVE ANALYSIS OF DEFORMITY AND PLAN OF RECONSTRUCTION

Before attempting the correction of any nasal abnormality, it is paramount to have a clear mental picture of the final result to be achieved. In any

disfigurement of the nose, there has been either loss of tissue or perhaps distortion of one or more of the component parts of the nasal framework from the position normally occupied in relation to one another or to the facial surroundings as a whole. In other instances, there may be both loss of tissue and malposition of the segments. Since noses are of infinite variety, contour, and configuration, it is imperative when planning the reconstruction, and most important during the execution of the repair, that the final result should be made to blend and harmonize with the configuration of the surrounding head and face of which the nose is the most important part. Because of the wide normal variation, the correct proportions of a given nose will for the most part depend upon the character of the structures which immediately surround it. The final judgment will be based on the operator's experience. The aim of reconstruction then is not to obtain perfect symmetry, but to bring an abnormality within the range of normal variation (Fig. 7).

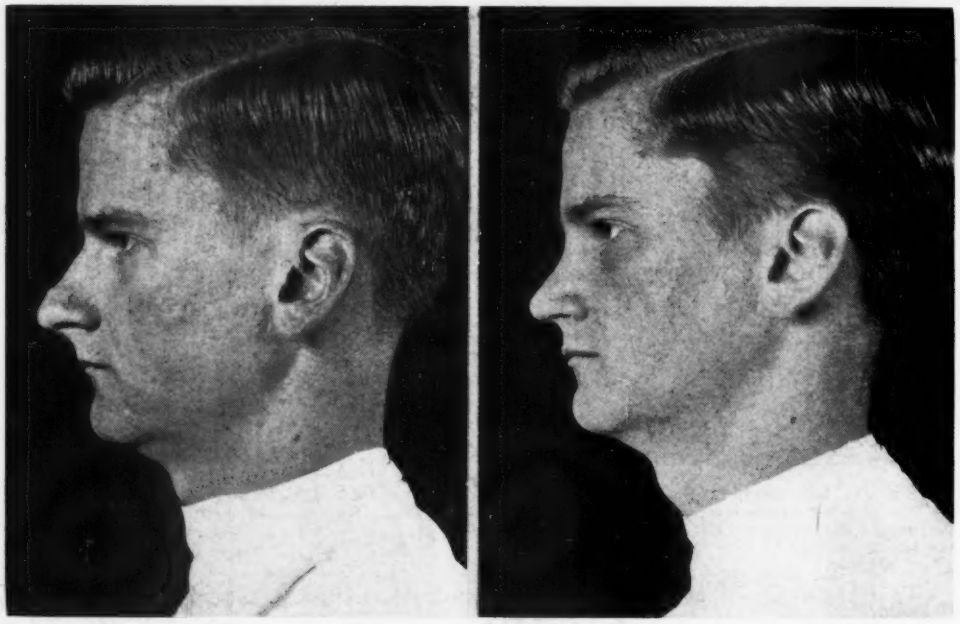

Fig. 7.—Webbing of the upper lip, associated with a slight hump, causes an optical illusion simulating a receding chin. The nasolabial angle is corrected by removing a small segment from the anterior border of the septum and the anterior nasal spine, and then using the Aufricht[3] procedure to draw the lip back to normal position.

In addition to the proper technical approach, which in itself is a prerequisite, one must exercise a definite esthetic sense in deciding the extent of the desired change (Fig. 8). Beyond the esthetic judgment, structural visualization of the anatomic architecture is likewise essential. While a thorough knowledge of the anatomy, physiology, and surgery of the nose is a sine qua non, the artistic creative power is the important factor in the success of the operation. Aufricht[3] has said, "This esthetic sense can be developed with training and experience if there is an inborn foundation for it; if not, it is as futile as attempting to make a musician of one who is tone deaf."

Fig. 8.—A long pointed nose with a small hump produces an unsightly deformity, corrected in a single operation. The artistic creative power is the important factor in the success of the rhinoplastic operation, which may change the patient's entire facial appearance.

After establishment of the *esthetic diagnosis* of an abnormal nose, the next step is the study of the face and visualization of an improved substitute. A *photographic record* is most essential: (1) Slight abnormalities overlooked in the visual examination may immediately become apparent in the photographs. Photographs are useful not only in the study of the deformity, but also at the time of the operation, when contours are obscured by infiltration and edema. (2) Photographs are more easily and quickly comprehensible than a written description, and (3) are the best means of comparing pre- and postoperative conditions. (4) They also serve to remind the patient of the original appearance, which may be soon forgotten; (5) they may be indispensable for medicolegal purposes; and finally (6) they are invaluable for teaching purposes.

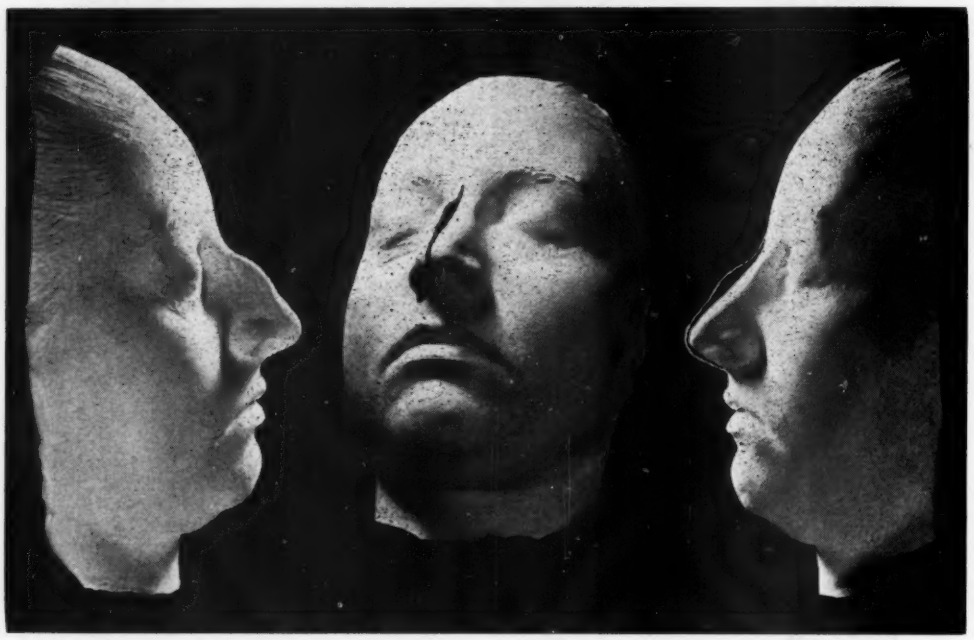

Fig. 9.—Casts of the face, plaster, wax, or lead, will assist in evaluating the deformity and planning the reconstruction. They are simple to make, inexpensive, and those of lead or other metal can be boiled at the time of operation. Beeswax or paraffin casts can be melted down and used repeatedly. One side of the plaster cast may be shaved down in hump noses or built up in saddle deformities and then accentuated with India ink, as illustrated.

A *plaster cast* or one made of wax will assist in evaluating the deformity and planning the reconstruction. One side of the cast may be sculptured or trimmed down to the desired level, in the presence of the patient, if this is desired. If there is a depression or saddling deformity, one side can be built up with modeling clay or one of the various plastic materials (Fig. 9). A cast is especially important in planning the reconstruction of a receding chin.

Mechanical Devices for Measurement.—To aid in reconstructing more accurately the nasal contour, Straith[5] has devised a very useful profilometer. This ingenious measuring device has been most helpful in planning the transformation as well as in the execution of the operation, for it can be boiled with the instruments. Berson[6] and Fomon[7] have also developed measuring devices.

Aufricht[3] has described a valuable procedure which, in addition to being very simple, is carried out directly on the skin of the nose at the time of the operation.

OPERATIVE PROCEDURE

Preoperative Preparation.—While the tissues of the nose possess marked local immunity and are very tolerant to contamination, it is also true that infection, when it does occur, is fraught with serious consequences. Aseptic principles must, therefore, be carefully observed. The vibrissae are clipped close and the vestibule is carefully and gently cleansed. The nostrils are quite tightly packed with one-half inch gauze packing which is moistened with 2.5 per cent pontocaine or 10 per cent cocaine and then wrung dry. This packing, preventing the escape of blood into the nasopharynx, is allowed to remain in place throughout the operation. Caution must be exercised in the use of cocaine, which is highly toxic and to which some individuals are extremely sensitive. Several drops of sterile mineral oil or castor oil are placed in the eyes, following which the routine preparation of the entire face is carried out and sterile drapes applied. The nose may now be marked with a 5 per cent alcoholic solution of brilliant green using the Aufricht procedure[3] or a Straith profilometer[5] as a guide to determine the amount of correction necessary.

Local anesthesia is the method of choice. A solution of 2 per cent procaine to which has been added 10 drops of adrenalin per ounce is not only an excellent anesthetic agent but, in addition, is helpful in effecting hemostasis. Sites of injection are selected to anesthetize the infraorbital, infratrochlear, and nasociliary nerves. In those instances when local anesthesia is undesirable, endotracheal inhalation is the best method.

Smith,[8] Safian,[9] Sheehan,[4] Brown,[10] Fomon,[7] and others have already described and illustrated the operative correction of various nasal deformities. Perhaps the most common type of nasal disfigurement is the long nose with a hump (Fig. 10), and hence the correction of this type of deformity is described here.

Incision.—The tip of the nose is elevated by engaging the alar rim with a small retractor held between the thumb and the index finger, while the middle finger exerts pressure on the outside of the nose, thus emphasizing the shelf between the lower end of the upper lateral cartilage and the superior border of the alar cartilage. Here a small intercartilaginous incision is made on each side, severing the aponeurosis connecting the two cartilages, and brought toward the midline to meet its counterpart (Fig. 11, *A*). A long button-end scalpel is then introduced through one incision, carried over the dorsum until it appears through the opposite incision, at which point it is turned at right angles. It is then brought downward, curving around the anterior tip of the septal cartilage and hugging the inferior margin of the septal cartilage, to cut through the membranous septum almost to the nasal spine. The incision should not cut either the columellar cartilage or the septal cartilage but simply pass between them (Fig. 11, *B*).

Undermining.—The skin over the root of the nose and the adjacent parts is thin and loose and lends itself readily to plastic surgery. A small blunt

scissors, double-edged scissors, or scalpel is then introduced through the intercartilaginous incision and undermining effected superficial to the upper lateral cartilages—superiorly as far as the glabella and laterally as far as the nasofacial fold (Fig. 11, *C*). No unsevered shreds of tissue should remain connecting the skin to the nasal framework beneath.

Removal of the Hump. In the step to remove the hump, a Straith profilometer[5] or the predetermined indelible marks suggested by Aufricht[3] will aid the operator in judging the amount of bone and cartilage to be removed. A photograph or cast will also prove helpful (Fig. 9). Using a periosteal elevator, the periosteum is pushed aside along the level at which the hump is to be removed. If the septal attachment of the upper lateral cartilage is still intact, it may then be divided close to the septum with a straight scissors.

Fig. 10.—The entire profile line is altered by corrective rhinoplastic surgery. By preserving the glabellar angle and elevating the tip, the chin is seemingly thrust forward, thereby removing the optical illusion of a receding chin.

The hump is then removed either with a saw or chisel. Both require care and practice and neither possesses marked superiority. A personal preference is a fine bayonet-shaped saw which is inserted through the original intercartilaginous incision and placed on the level of the normal profile. The nasal bone is then sawed through carefully, severing the bony septum at the same level as the nasal bones (Fig. 11, *D, E*). This same procedure is performed on the opposite side using the other saw.

It will be found that the hump is still attached to the juncture of the nasal bone and the cartilaginous septum. A blunt-pointed, straight-edged scalpel or an angulated knife is inserted under the severed bony hump and drawn downward and slightly forward to include a thin portion of the dorsum of the cartilaginous septum (Fig. 11, *F*). The hump can then be withdrawn

with a pair of tissue forceps or a clamp (Fig. 12, *A*). The somewhat rough and uneven edges of the bone are then smoothed off with a rasp introduced first through one and then through the other incision (Fig. 12, *B*). Owing to its elasticity, the skin, if sufficiently undermined, adjusts itself to the newly shaped nasal framework no matter how large a section of bone has been removed.

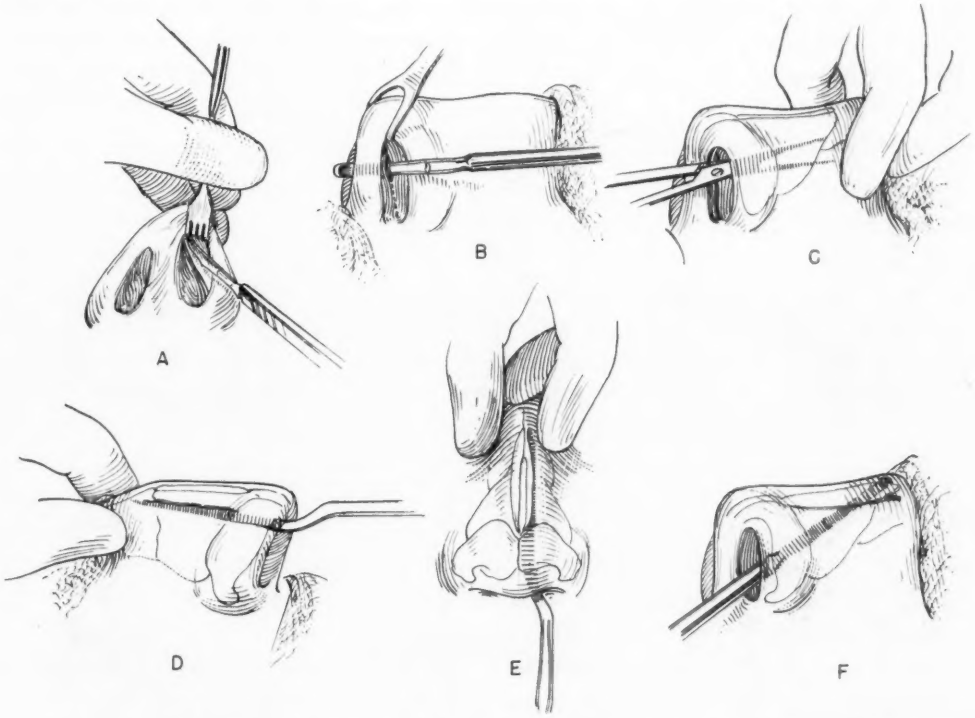

Fig. 11.—Technique of corrective rhinoplasty. *A*, The tip of the nose is retracted, and an incision is made between the upper and lower lateral cartilages, severing the aponeurosis connecting the two cartilages. A similar incision is made on the opposite side. *B*, A blunt-point scalpel introduced through one incision appears through the opposite incision and is then brought downward between the septum and columella to the nasal spine. *C*, Skin is undermined laterally to nasolabial folds, medially to the dorsum, and superiorly to the glabella. After elevating the periosteum, a bayonet saw is introduced through the intercartilaginous incision to cut through the bony and cartilaginous elements (*D*, lateral view; *E*, dorsal view). After sawing through one side, the other saw is inserted through the opposite side and the procedure repeated. *F*, Button-end knife is introduced beneath severed bony section and drawn down to tip of nose, completely freeing all elements.

Narrowing of the Nasal Bridge.—After removal of the hump, the excessive width of the bridge of the nose becomes markedly accentuated due to the gap between the resected edges of the nasal bones. For this reason, as emphasized by Safian,[9] Aufricht,[3] and others, it is always necessary to narrow the nasal bridge, regardless of the smallness of the hump, in order to avoid a flat appearance of the dorsum from a frontal view. An incision is made in the vestibule at the nasofacial junction overlying the pyriform opening. The scalpel or scissors are carried upward toward the inner canthus, separating the skin from the circumjacent structures. The periosteum along the proposed bone incision is displaced with a raspatory. A right-angle or bayonet saw, or a chisel, as recommended by Sheehan,[4] is introduced subperiosteally in such

a manner as to permit the saw blade to rest upon the denuded frontal process of the superior maxilla flush with the face and with its point directed midway between the glabella and inner canthus (Fig. 12, *C*). With the position of the saw maintained with the two fingers of the opposite hand, the bony process is sawed through with rapid strokes. The same procedure is repeated on the opposite side, the operator being certain that the line of fracture on each side is in the same location. The entire bony side of the nose may then be advanced toward the midline by exerting pressure with the thumbs, disrupting the attachment of the nasal bone to the frontal bone. This *infracturing* technique of Joseph[12] (Fig. 12, *D*) will have the effect of closing the gap between the resected edges of the bones and narrowing the bridge.

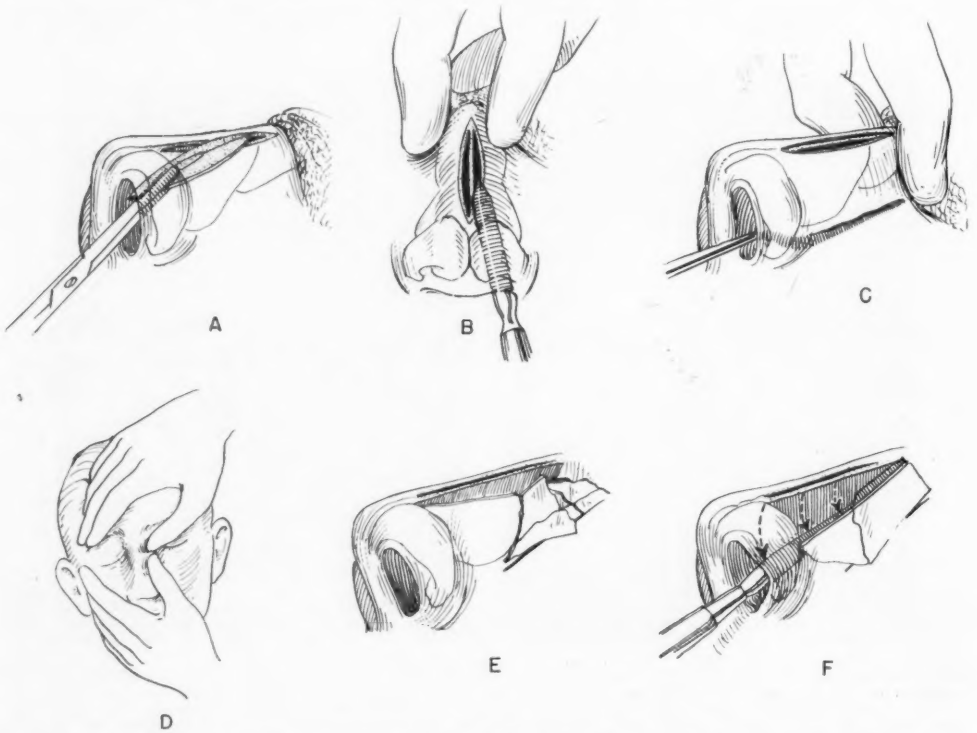

Fig. 12.—Technique of corrective rhinoplasty continued. *A*, The hump is withdrawn with a clamp or forceps. *B*, In palpating the skin of the dorsum, one notes three distinct structures: the two cut edges of the nasal bone, one on each side; and the edge of the septal cartilage. If these edges are rough or irregular, they should be smoothed down with a rasp. *C*, A small incision is made over the pyriform opening and a raspatory introduced to elevate the periosteum along the proposed bone incision. A nasal saw is introduced to permit the blade to rest subperiosteally upon the denuded frontal process of the superior maxilla in the nasofacial groove and the point directed midway between the glabella and inner canthus. Fingers of opposite hand protect the eye and maintain the position of the saw. The procedure is repeated on the opposite side. *D*, Nasal bones are mobilized toward midline by direct manual pressure. *E*, Typical comminuted fractures occurring with infracturing technique to narrow the dorsum. The radix nasi has not been fractured. *F*, Aufricht's[3] outfracturing method: A chisel is used to cut through the bony web of nasal bridge and radix nasi. Then, using downward and outward pressure, the chisel levering from the frontal bone, the entire fragment is mobilized outward following which it can be pressed inward with ease to establish the new line of the nasal arch.

Aufricht,[3] however, has found that quite frequently "the bony side of the nose, instead of being fractured off or disarticulated in one piece at its junction with the frontal bone, will break somewhere in its upper third; at times

a sharp spicule will remain firmly attached to the radix nasi. The bony side often breaks in more than one piece causing a comminuted fracture'' (Fig. 12, *E*). ''The most disappointing experience, however, is that even after the bony sides have been completely disarticulated from their frontal attachment and have been pressed toward the center, the dorsum will still remain wide.'' This is explainable anatomically since the bony dorsum and the radix nasi are entirely different: the bony septum is thin and hollow, while the radix nasi is solid and massive. To correct this undesirable occurrence, Aufricht[3] stated, ''Instead of fracturing the nose inward from without, I fracture it in the reverse direction—outward from within. With 'outfracturing' there is less resistance to overcome, and there is more room for levering. Second, I divide the existing bony connection at the radix nasi. Third, I remove the bony web from within the dorsum, and a corresponding segment from the radix nasi when necessary.''

In Aufricht's *outfracturing* technique the scissors, osteotome, or chisel is inserted close to the septum and with moderate force the remnant of the bridge and the radix nasi are cut through, then the bony side is moved outward, the chisel levering from the frontal bone (Fig. 12, *F*). After being so mobilized, the bony sides can be pressed forward toward the midline with ease.

Reduction of a Wide Nasal Tip.—Careful attention to details in remodeling the nose often determines the success or failure of the procedure. Large nostrils, flaring alae, bulging base of the nostrils, and improper direction of the alae are the most common shortcomings of the operation. As noted previously, Sheehan[4] has emphasized the necessity for delicate handling of the lateral extension of the alar cartilages. The configuration of the nostrils is directly dependent upon the size, position, and contour of these cartilages.

In general, reduction in size of the alar cartilages, without greatly changing their form, may be accomplished with the method described by Safian.[9] A short incision is made inside each alar rim close to the columella (Fig. 13, *A*). The alar cartilage is then mobilized by undermining the subcutaneous tissue and the skin over it, as far superiorly as the original intercartilaginous incision, and laterally along the entire width of the cartilage. This undermining is nicely accomplished with a small pointed scissors. The mobilized alar cartilage is made to present in the vestibule and is severed with a scissors at its medial angle close to the columella (Fig. 13, *B*). Removal of a section of cartilage and vestibular mucous membrane along the incised border will permit reduction in size and contour, equal to the combined width of the sections of cartilage excised. Lamont[11] does not disturb the nasal lining. The excised cartilage will have the shape of a hockey stick (Fig. 13, *C*). This procedure has the effect of reducing the roundness of the nasal openings which usually accompanies excessive width of the alar cartilages (Figs. 13, *D*, *E*, *F*). Elevating the tip of the nose will temporarily accentuate the roundness. While Safian[13] believes that the alar cartilages should never be completely removed, Kitlowski[14] frequently removes the alar cartilages in their entirety, without the shrinkage or pinched-tip effect which one might expect.

Shortening of the Nose, Elevation of the Tip.—If the upper lateral cartilages have not already been severed from the septum, they are divided close to the septum in the intervening angle; but trimming is deferred until later. The soft tissues over the bridge of the nose are retracted upward, and the anterior end of the septum is made to present through the left nostril (Fig. 14, *A*). Then, by judging from the predetermined measurements made at the beginning of the operation with the Straith[5] profilometer or the Aufricht[3]

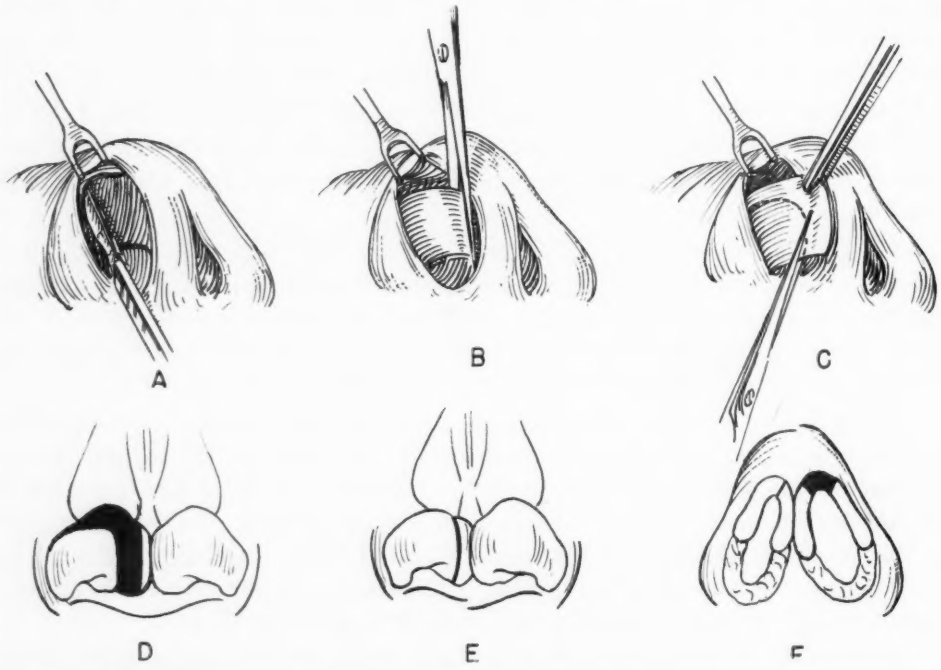

Fig. 13.—Technique of corrective rhinoplasty continued, narrowing the tip of the nose. *A*, An incision is made along the lower border of the alar cartilage. The skin over the dorsal surface is undermined along the entire width of the cartilage. *B*, A small hooked retractor is inserted into the upper angle of the nostril, and the alar cartilage made to present in the vestibule. The angle of the alar cartilage thus brought into view through the nostril is incised with a scissors along its width, close to the septal margin. *C*, Removal of a hockey-stick shaped section of cartilage and nasal lining along the incised border will permit reduction in size and contour, equal to the combined width of the sections of cartilage excised. This will also reduce the rotundity of the nasal openings which usually accompanies excessive width of the alar cartilages. *D*, Area of cartilage excised. *E* and *F* show effect of resection of alar cartilages, superior and inferior views.

procedure, a triangular section of cartilage of a size sufficient to effect the required shortening is removed, the base of this triangle being directed upward and the apex toward the nasal spine. The tilt of the nose is governed by the size of the cartilage excised. The nose should be shortened to an extent somewhat less than the length of the chin line, but extreme conservatism should be practiced inasmuch as excessive shortening is not only unsightly, but may be difficult to correct. It is much better, when in doubt, to shave it down gradually and test to see when the desired elevation is obtained (Fig. 14, *B*), rather than to remove too great an amount in a single section, and regret it.

Attachment of the Columella to the Septum; Trimming of the Triangular Cartilages.—When the nose has been reduced and the alar cartilages altered, the columella is anchored to the septal cartilage with two medium silk sutures on Keith needles, one on each end of the thread (Fig. 14, *C*). The needles pass through the entire thickness of both structures. To compensate for the subsequent contraction, about 2 mm., inevitably taking place along the line of union, and the resulting drop of the tip of the nose of the same distance, the stitches should be placed obliquely so that when they are tied the tip will tilt slightly forward and upward (Fig. 14, *D*). After the sutures are tied, it will then be found that the upper lateral cartilages, which are now too long for the shortened nose, protrude for a considerable distance into the vestibule. Unless the redundant upper lateral cartilages are trimmed to correspond with the septal shortening, the lower half of the nose will appear unusually thick. Therefore, both the medial and inferior margins are trimmed down so that the edges of the mucosa

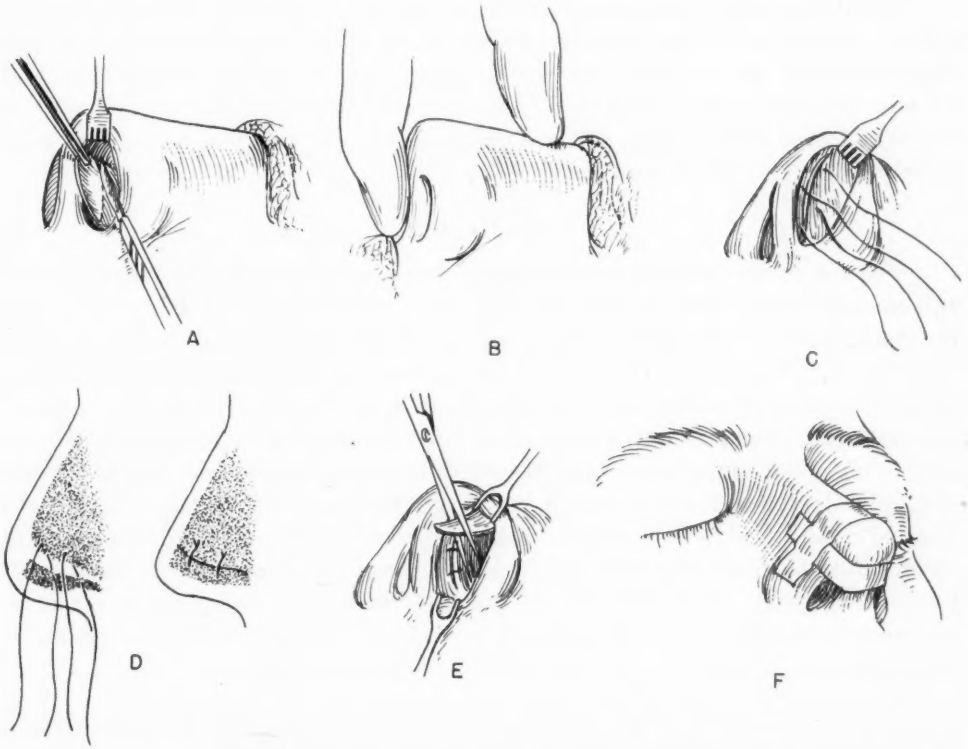

Fig. 14.—Technique of corrective rhinoplasty continued. Shortening of the nose, elevation of the tip: *A*, A toothed forceps holds the septum rigid while the retractor holds the alar rim and columella out of the way. The dotted line indicates the triangular segment of septum to be excised. It is preferable to shave it down gradually and test to see when the desired elevation is obtained (*B*), rather than to remove too much and produce an excessive shortening. *C*, The columella is reattached to the septal cartilage by two medium silk sutures. The tip of the nose may be raised or lowered with these sutures. *D*, To raise the tip, the through-and-through sutures are inserted so that they pass through a more anterior point in the fixed septum than in the columella. The threads are tied so that the columella and the tip of the nose advanced forward and the sutures extend vertically across the incision. *E*, The redundant upper lateral cartilages are trimmed to correspond with the shortening of the septum. *F*, New position of lower lateral cartilages maintained with adhesive or cellophane tape. Splint, stent, or brace is then applied.

are again in apposition (Fig. 14, *E*). Since the edges of the intercartilaginous incisions fall into apposition, they may be left without sutures if desired.

Dressing and Immobilization.—After compressing the nose from above downward to expel blood and clots, the intranasal packs are removed and the nostrils may be packed again lightly with a grease-impregnated gauze. Although the nasal muscles are vestigial and not capable of causing displacement of the parts, it is still desirable to immobilize the nose for the first forty-eight hours, not only to offset the possibility of accidental disturbance of the fragments, but, in addition, to reduce swelling and discoloration. Various methods of immobilization have been described, all of which are simple and satisfactory: the dental stent recommended by Aufricht,[15] the metal splints used by Blair and Brown,[1] the small brace designed by Safian,[9] or straps of adhesive tape without other support as used by Lamont[11] (Fig. 14, *F*). The splint or brace is allowed to remain for two days, the nostrils cleansed, and, if desired, the adhesive straps and brace may be reapplied.

Following nasal reconstruction, most patients have very little discomfort and are ready for discharge in about one week. The columellar-septal sutures should remain for at least one week. Each patient is told in advance that he will develop "two black eyes" and can thus adjust his professional or social calendar accordingly, for in some instances the ecchymosis will not completely disappear for two or more weeks.

CONCLUSION

Because of the natural prominence of the nose, any nasal deformity is conspicuous and frequently is the only blemish of an otherwise pleasing face. The reconstruction of the defects by those properly trained and qualified offers very little difficulty for the patient and, properly performed, will in a great many instances result in a greatly improved general appearance. The psychic importance of reconstructive surgery of the nose has been emphasized. A comparatively simple operation, performed under local anesthesia, often relieves the patient of a deformity which has been the source of mental anguish and anxiety. Although a face may or may not be a fortune, the importance of its appearance receives the greatest emphasis when the face or nose happens to be a misfortune. The counsel of "patient resignation" too often given by physicians and friends is unkind and unsound in the light of surgical achievements in plastic surgery. Some of these have been presented.

The author is indebted to Dr. Joseph Beard and Miss Frances Powe for advice and assistance in the preparation of the manuscript; to Mr. Norrie Parkes and Mr. Robert Little of the Department of Medical Illustration for the drawings and photographs.

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Book Reviews

Pneumoperitoneum Treatment. By A. L. Banyai, M.D., F.A.C.P., pp. 376, with 74 illustrations, St. Louis, 1946, The C. V. Mosby Company.

The author of this monograph is most qualified by the duration and extent of his experience to write on this subject. He contributes a valuable reference book on the basis of his own experience and an exhaustive coverage of the world literature. The bibliography lists almost 700 references, including 24 of his own contributions to the use of pneumoperitoneum. Everything pertaining to this method of treatment is included in the text and the references. The chapter devoted to the technique of administration will be found valuable. Less than one-half of the text discusses the technique and application of pneumoperitoneum to the treatment of pulmonary tuberculosis while the remainder covers its possible application to ten other conditions in which its utility at best is doubtful. The discussion of physiologic changes has some statements of questionable validity with regard to the subdiaphragmatic pressures. The numerous illustrations are roentgenograms which show the gross effects of pneumoperitoneum adequately. On the whole, this book includes so much material with so little critical evaluation that it should be read with the thought in mind that pneumoperitoneum is still under trial as a method of treatment and can at most be only supplementary to other methods which either treat the whole patient or attach the problem of pulmonary disease and infecion more directly.

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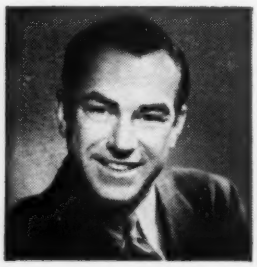

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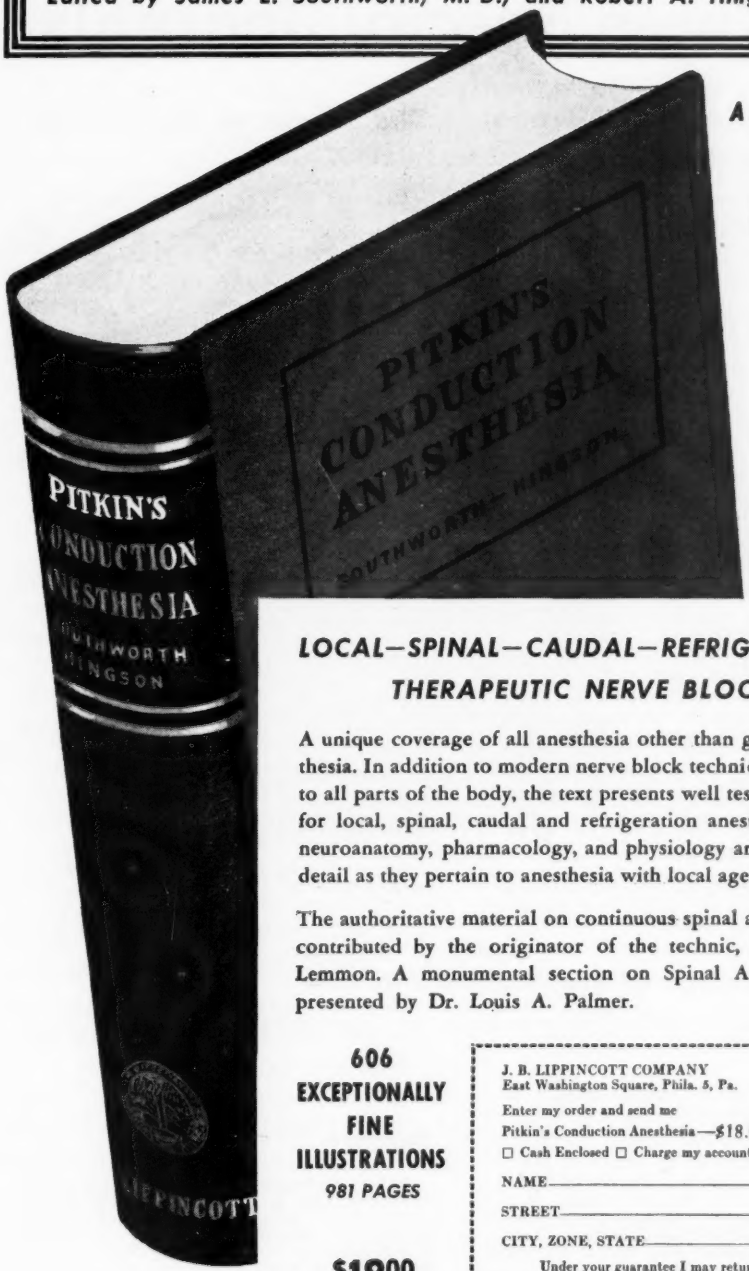

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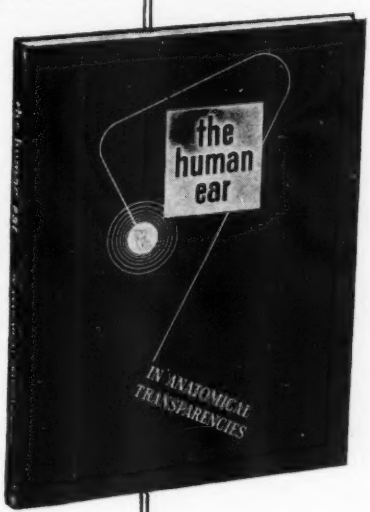

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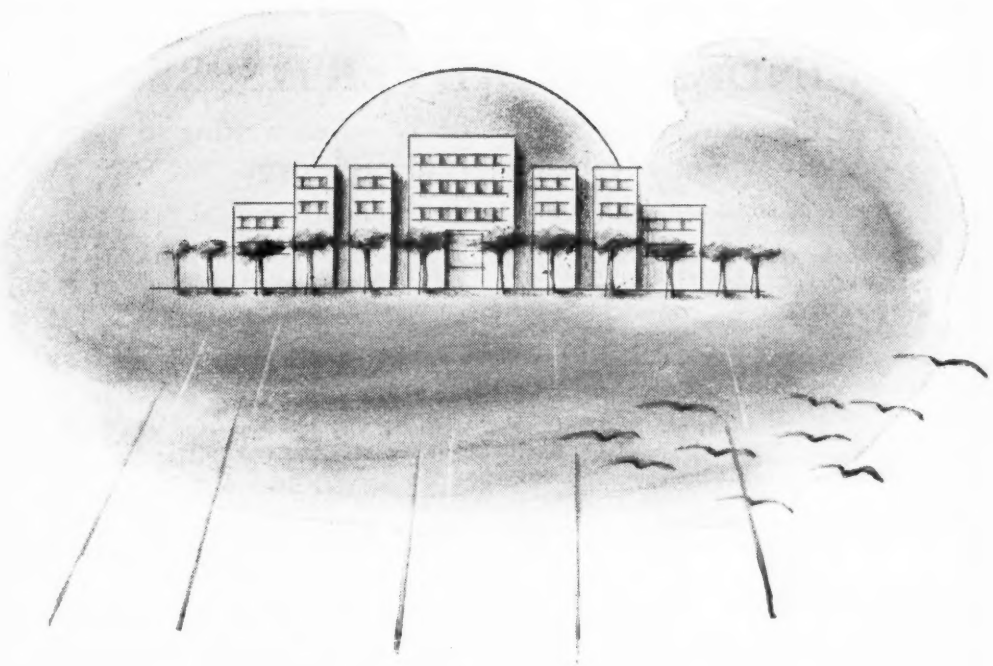

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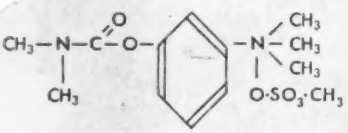

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